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FIRE CONTROL NOTES

U.S. Department of Agriculture
Forest Service

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

CONTENTS

INFORMATION FOR CONTRIBUTORS

Please submit contributions through appropriate channels to Director, Division of Fire Control, Forest Service, U.S. Department of Agriculture, Washington, D.C. 20250. Articles should be typed in duplicate, double space, and with no paragraphs breaking over to the next page. Elite and pica copy should be 54 and 45 spaces wide, respectively.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and organization.

Authors are encouraged to include illustrations with their copy. Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints or India ink line drawings are acceptable. Captions for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the caption being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

When Forest Service photographs are submitted, the negative number should be indicated with the caption to aid in later identification of the illustrations. When pictures do not carry Forest Service numbers, the source of the picture should be given, so that the negative may be located if it is desired.

COVER—The Redmond, Oreg., Air Center was dedicated on August 29, 1964, by the U.S. Forest Service. It is the hub of aerial firefighting operations for the Pacific Northwest. The Air Center is home base for smokejumpers, air tankers, air cargo planes, and an interregional fire suppression crew that may be flown anywhere in the West.

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SIMULATING FOREST FIRES FOR RESEARCH

ROBERT C. HARE, *Plant Physiologist,*
Institute of Forest Genetics,
Southern Forest Experiment Station[1]

The effects of a forest fire on a single tree can be simulated by burning an oil wick encircling the tree near groundline. Some of the advantages of this method over the setting of fires in natural fuel include ease of replication, standardization of amount of heat, a saving of labor, and low risk of fire escape. Trees are also conserved, for only those needed are burned, whereas natural-fuel burns usually damage many trees not used in a study.

Figure 1.—Wick braided from wire-reinforced asbestos and saturated with SAE-30 motor oil in kerosene is wrapped around the trunk and ignited.

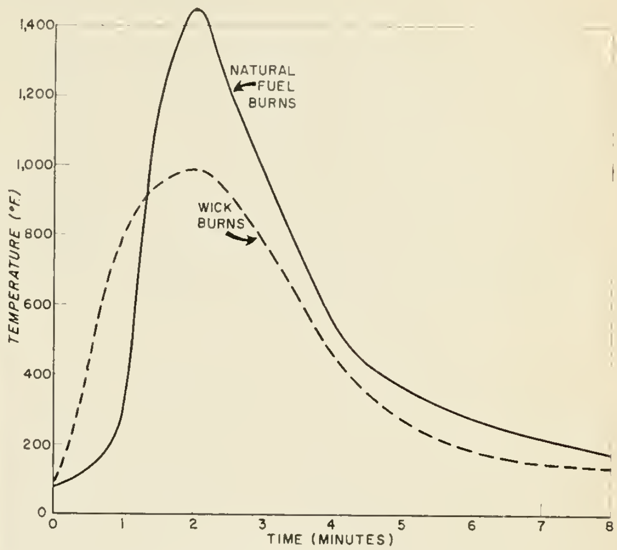

Figure 2.—Typical lee-side, bark-surface temperature curves 1 foot above the wick and in natural-fuel burns.

The wick, braided from wire-reinforced asbestos and saturated with SAE-30 motor oil in kerosene (1:3), is wrapped around the trunk about 1 foot off the ground, and ignited after litter is removed (fig. 1). Temperature regimes on and under the bark are recorded by thermocouples connected to a multiple recorder.

Wick flames, lasting about 7 minutes, give temperature histories on both windward and lee sides that are quite similar to those obtained in natural-fuel burns (fig. 2). Maximum cambium temperatures in a number of tests varied from 85° to 520° F. in wick burns, and from 85° to 500° in pine-litter burns.

Although the wick fire cannot reproduce a moving front, it responds to wind much as natural fires do. Because of a cooling effect on the windward side and a convection column buildup on the lee side, maximum lee temperatures in both types of fires are at least twice as high as windward maxima, and the difference increases with height.

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[1] This research was conducted when the author was with the fuels and fire control project at the Southern Forest Experiment Station.

VORTEX TURBULENCE—ITS EFFECT ON FIRE BEHAVIOR

JAMES B. DAVIS, *Forester,*
Pacific Southwest Forest & Range Experiment Station
and CRAIG C. CHANDLER, *Fire Behavior Specialist,*
Forest Fire Research, Washington Office[1]

"The fire wasn't doing much until the air tanker went over, and then it spotted all over the place," complained the fire crew foreman.

Such reports have caused fire control officers to ask, "Can air tankers really cause erratic fire behavior?" The answer is yes—under some conditions. The gremlin is "vortex turbulence," a pair of whirlwinds streaming out behind the wingtips.

What is Vortex Turbulence?

Vortex turbulence is a sheet of turbulent air that is left in the wake of all aircraft. It rolls up into two strong vortices, compact fast-spinning funnels of air, and to an observer on the ground appears to trail behind each wingtip (fig. 1). Because it moves out at right angles to the flight path, vortex turbulence can be distinguished from propeller wash, which is largely localized to a narrow stream lying approximately along the flight path. Unfortunately, however, vortex turbulence is usually invisible.

Under certain conditions the two vortices may stay close together, sometimes undulating slightly as they stretch rearward. The interaction between them tends to make them move first downward, then outward along the surface of the ground.

How Important are Vortex Wakes?

The Flight Safety Foundation, Inc., reports: "In recent years, there have been increasingly frequent reports by pilots encountering severe disturbances of another airplane even when separated from it by distances of several miles. There also are an increasing number of fatal accidents to lighter airplanes, resulting from upsets near the ground or structural failures which are being ascribed to encounters with wakes of large airplanes. It is now generally accepted that the only disturbance which an airplane can produce that is powerful and persistent enough to account for these incidents arises from the vortices which trail from the wingtips of any airplane in flight."

Ordinarily, vortex turbulence does not pose any difficulties to fire control forces. But under special circumstances vortex wakes may cause a fire to act most unexpectedly. Line personnel should become familiar with the vortex problem and the situations where it is likely to affect fire behavior.

What Causes Vortex Turbulence?

Vortex turbulence is a byproduct of the phenomenon that gives lift to an airplane. Air flowing the longer route over the top of the wing has to travel

Figure 1.—Low-flying spray plane. Note funneling effect of spray trailing behind each wingtip. This is vortex turbulence.

[1] The authors have received technical guidance from many sources but are especially grateful to Richard C. Rothermel, Aeronautical Engineer, Northern Forest Fire Laboratory; Herbert J. Shields, Supervisory Engineer, Arcadia Equipment Development Center; and Alan W. McMasters, Operations Analyst, Pacific Southwest Forest & Range Experiment Station.

faster than the air flowing across the bottom in order to reach the trailing edge simultaneously. The difference in speed causes a difference in pressure between the top and bottom of the wing with a resultant upward force, or lift. If you want to demonstrate this effect, hold the back of a spoon in a stream of water from a faucet. The spoon will be pulled into the stream as soon as the water touches it. However, here is where the trouble starts. Since the air pressure is greater on the under surface of the wing than on top, some air tries to flow around the end of the wing to the lower pressure area. Because of the flow around the tip, the main stream—instead of flowing straight back across the top and bottom of the wing—tends to fly inward toward the fuselage on the top of the wing and outward on the bottom. As a result, the air doesn't "fit together" at the trailing edge but forms a vortex sheet that rolls up into two large whirlwinds that trail from each wingtip (fig. 2).

Is Turbulence the Same for All Air Tankers?

Vortex severity and persistency vary with several factors. Most important are the type and size of the aircraft and the condition of the air. Vortex turbulence is greatest when produced by a large aircraft with a heavy wingspan loading. Thus, the heavier the aircraft or payload per unit of wing surface, the more severe the turbulence will be. The B-17 is a heavier airplane than the PBY. Thus, when the vortex wake immediately behind a B-17 is 29 m.p.h., the lighter PBY's vortex will be only 16 m.p.h. under the same flying conditions since both planes have the same wingspan.

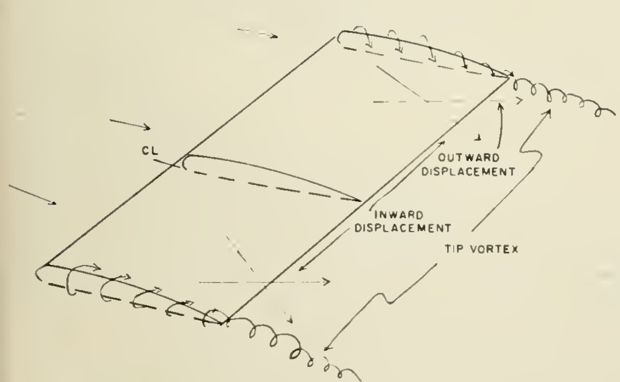

Figure 2.—Airflow over wing with distortion of flow and vortex formation.

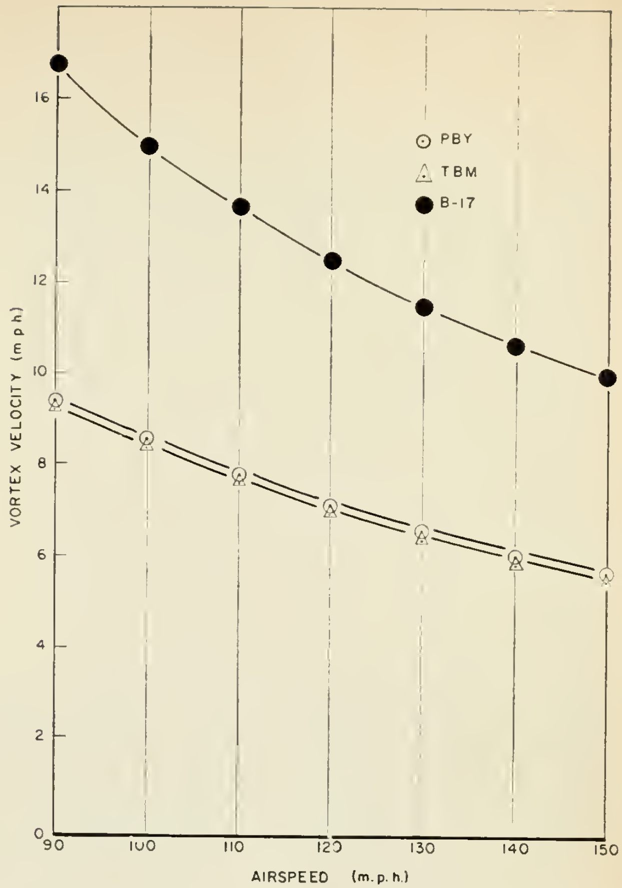

Figure 3.—Relation of vortex velocity to air tanker speed. The tanker's altitude was 75 feet; vortices took about 15 seconds to reach the ground, where their velocities were obtained.

How Does Air Tanker Speed Affect Turbulence?

It may seem surprising, but turbulence is inversely related to airspeed (fig. 3).

Other factors being equal, an aircraft with a high wingspan loading at slow airspeed is the source of the strongest vortices. In terms of air safety, one of the greatest hazards is a heavily loaded aircraft flying at slow speeds before landing or after takeoff. Essentially, this is the condition when an air tanker slows down for an accurate airdrop.

How Does Aircraft Height Affect Turbulence?

At high altitude, the two vortices remain separated by a distance slightly less than the aircraft's wingspan. However, the interaction of the two causes them to drop. As they approach within approximately a wingspan of the ground, they begin

to move laterally outboard from each wingtip. The lateral motion may be better termed "skidding" than "rolling," for at the ground contact point the direction of rotation is opposite the core's lateral movement (see fig. 2). The downward movement may require only 10 seconds from a TBM flying at 50 feet, but a minute or more from the same aircraft flying at 150 feet. The time required for downward movement is important for two reasons:

1. Wind can blow the vortices away from the drop area. For example, a 10-m.p.h. wind can blow the vortices more than 800 feet in the short time required to drop from 150 feet.

2. Vortices weaken rapidly with time. Under average air conditions, the turbulence may lose its danger potential in less than a minute. In rough air, the funnels break up and weaken even more rapidly. Calm air is the worst situation because it permits the turbulence to persist for a longer period.

How Does Vegetation Affect the Vortex?

Natural surfaces are more or less rough and, therefore, cause frictional resistance to air movement above them. The rougher the surface, the greater the friction. Timber, for example, has a much greater slowing effect on wind than does open grassland. Whereas a vortex turbulence is more like a horizontal whirlwind than what we normally think of as a wind, the same frictional considerations apply. A heavy stand of timber would dissipate most of the force of a vortex; the same vortex would be only slightly weakened in grass or scattered timber.

How Do Vortex Wakes Affect Fire Behavior?

Although there are many observations on the effect of vortex wakes on other aircraft, we have

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Figure 4.—Wake from a DC-3 and pronounced vertical motion of the vortex.

LOOKOUT VISIBLE AREA—ILLUMINATED AND PHOTOGRAPHED

CLAUDE PHILLIPS, *Forester,*
Oregon Forestry Department

Because of changing fire detection systems there is recurrent need for lookout visible area charts. Office or field methods of charting seen area require tedious sketching.

The darkroom photographic method developed in the Oregon Forestry Department eliminates much of this effort and produces new features on the charts. Reference to flashing light on relief models is found in Davis (1959)[1] (photography is not mentioned). Modest exploration of the method's potential became possible only with the advent of plastic relief maps. This process was tested during a project requiring extended coverage for several lookouts on a district being considered for combination lookout and air patrol.

Concept

To illustrate the method, visualize taking a picture at night from a high altitude directly over the lookout while using a powerful flash at the lookout point for exposure lighting. The area illuminated and recorded in the picture would correspond to the area seen by the lookout. The area hidden from the lookout by ridges and canyons would be in shadow.

Utilization of Relief Maps

In practice, the same method is used on a miniature scale. Miniature terrain is provided by Army Map Service plastic relief maps with a horizontal scale of 1:250,000 and a vertical exaggeration of 2:1.

The tiny point source of light needed to match this miniature terrain might be difficult to obtain from light bulbs, lenses, or reflectors. Therefore, the flash from a small arc created at the lookout point on the map surface was used.

The map used in this project (fig. 1), which covered the Northwest Protection District of Oregon, was made by gluing together two of the "Wrinkle Quads." The main concern was over the accuracy to be expected of terrain impression and the effects of using the small scale of one-fourth inch per mile. On these relief maps with a vertical scale of 1:125,000, one-hundredth inch is equivalent to a tower height of 104 feet. The requirements of this project permitted the indication of slightly greater coverage than the ground surface really seen.

Figure 1.—Front of map used in darkroom method.

Measurement of the height of model terrain on the relief map with a surface gage revealed the map to be surprisingly accurate. Corrections of 0.01 to 0.03 inches were made by gluing balsa blocks to the back and trimming to support at the correct height before gluing the map to a ½-inch-thick fiberboard base. These blocks gave rigidity to the map when it was glued to the base for wiring.

Instrumentation

Holes were drilled through the map and the base at the lookout point, and wire electrodes were inserted until flush with the map surface. Under

[1] Davis, Kenneth P. Forest fire: control and use. 584 pp., illus. New York: McGraw-Hill. 1959.

the base the wires were bent flat (fig. 2), anchored with screws, and soldered to a common conductor. Map electrodes are made from number 18 copper magnet wire (0.040 inch diameter) with enamel removed. The arcing circuit was completed by a carbon electrode (penlight battery core) mounted on a slender adjustable support arm above the map (fig. 3). Current was supplied to the electrodes from 45- and 67½-volt B-type used radio batteries connected in a series to give 450 to 500 volts. The carbon electrode was connected positive through a momentary switch. Actual arcing was controlled by a fine adjustment screw in a leg of the stand supporting the overhead arm. The arm was lowered and raised to strike and break the arc as in welding. The switch protects against accidental flashes. Capacitors were tried successfully as a power source, but the arc created more sparks than the battery system and the recharging time was too long.

Figure 3.—Meeting of contacts showing map electrode slightly extended.

Application of The Method

Direct photography of the lighted area was the real expedient in this venture. It permitted a simultaneous record of geographic map, seen area, and composite coverage as desired. Pictures were made on Kodak Royal Pan film[2] by a 4 by 5 Speed-Graphic camera mounted on a tripod directly over

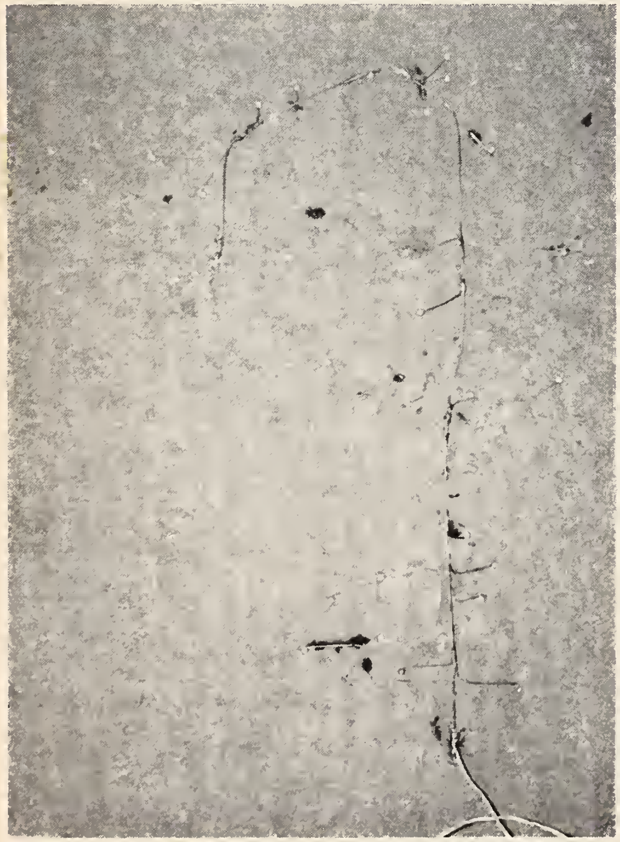

Figure 2.—Back of map used in darkroom method. Firtex backing and wiring detail is shown.

[2] Use of trade names is for information purposes and does not imply endorsement of products by the U.S. Department of Agriculture over other products not mentioned.

Figure 4.—Camera setup with map on darkroom floor; exposed portion of arcing circuit is shown.

the map in the darkroom (fig. 4). The aperture was f-8, and the exposures were made with an open shutter. Two to four flashes were used, depending on the quality and duration of the flash. Sustained arc with this power source can set the map on fire or overheat the wires. The shutter was closed for moving the contact on composite pictures, and a separate floodlight exposure was made at 1/150 second for map background lighting.

Light diminishes with distance at a rate somewhat comparable to visual perception, providing a gradual limit instead of the arbitrary 8-mile circle.

The seen area appears gradually darker farther from the lookout. This feature apparently helps in making a visual estimate of lookout potential. Also the recorded light is attenuated in the shadow of obstructions so that we have some representation of nearly seen surface. Areas slightly below the line of sight are only lightly shaded, indicating the area where it is possible to detect rising smoke.

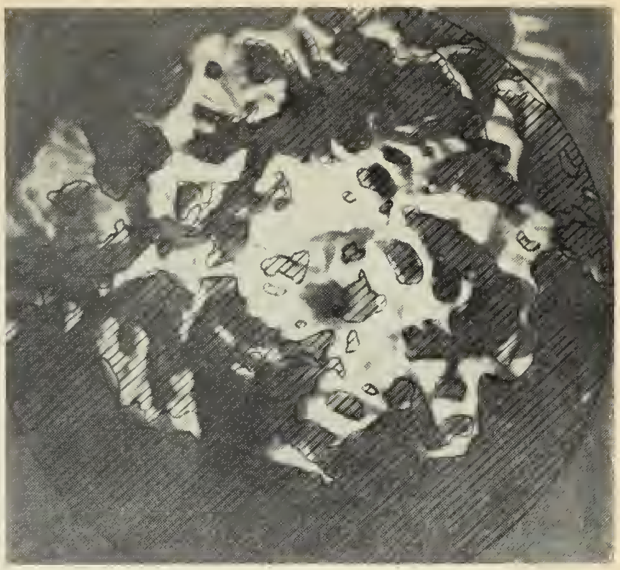

Figure 5.—King Mountain, Northwest District, showing overlay by profile method superimposed over photo. Unseen area of profile overlay is hachured. Discrepancies are partly due to slight scale differences and photo distortion.

Figure 6.—Point tried near the bend of Wilson River in Northwest District.

Comparison with Profile Method

Seen-area charts made by the profile method use 1-inch-per-mile topographic maps, and then the charts are reduced to a ½-inch-per-mile scale. The reduction method is subject to error and may account for much of the discrepancy between the photos and previously drawn charts done by the profile method (fig. 5).

It is not difficult to orient an overlay chart when

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Figure 7.—This composite photo shows seven selected points. There is attenuated but recorded light up to 15 miles. Background lighting brings out the printing detail of the map.

THE UNIMOG, A VERSATILE VEHICLE

Samuel S. Cobb, *Chief, Division of Forest Protection, Pennsylvania Department of Forests and Waters*

The Pennsylvania Department of Forests and Waters has consistently sought better means by which its personnel could reach and control all forest fires as quickly as possible.

Although Pennsylvania is populous and highly industrial, most of its people and extensive road networks are concentrated in small areas. Except for the coastal piedmont region in the State south of the Appalachians, the western fringe along the Ohio border, and a few wide agricultural valleys, the State is heavily forested. There are many large, unbroken blocks of forest. Fifty-two percent of the land area is in woodlands, and more than half of the 67 counties have forested areas of 60 to 90 percent.

In these heavily forested counties the road networks are sparse, especially in the mountains. Even in areas with large population centers, there are sizable forested blocks without roads or with only very poor roads.

Over the years, particularly since the end of World War II, many types of vehicles have been tested for use in off-the-road travel into such inaccessible areas. Many conventional four-wheel-drive trucks and military surplus four-wheel-drive vehicles have been tried. However, when any of these vehicles were used to traverse rough terrain, expensive breakdowns or crippling "hang-ups" sometimes occurred.

In 1958, Horace B. Rowland, then Chief of the Department's Division of Forest Protection, became interested in a vehicle called the Unimog[1] (figs. 1-3). Manufactured in West Germany by the Mercedes-Benz Company, it had been designed as a combination small truck and farm tractor for the European farmer. It was also quickly accepted as a valuable military vehicle by several European armies. Rowland had become interested in the vehicle's application as a fireplow unit. When two of these vehicles were delivered late in 1961, they were further equipped by the installation of an hydraulically operated Anderson fireline plow.

The vehicles delivered to the Division were the

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Figure 1.—Front view showing the guard shields that protect the grill, headlights, and windshield.

Figure 2.—Rear view showing the plow attached and the slip-on pump tank unit in place.

[1] Use of trade names is for information purposes and does not imply endorsement of products by the U.S. Department of Agriculture over other products not mentioned.

WOODS ARSONISTS AT WORK

JOHN E. BOREN III, *Criminal Investigator, Kisatchie National Forest*

It was 10:30 a.m. on March 22, 1964, on the Evangeline Ranger District, Kisatchie National Forest. A Forest Service lookout spotted a column of smoke. Before he could reach for his phone to alert a suppression crew he saw another, then another, then more. By 4:15 p.m. 89 individual incendiary sets had been recorded (fig. 1). The arsonist(s) had planned their work well.

Eleven tractor-plow units and 70 firefighters from the U.S. Forest Service and the Louisiana Forestry Commission limited several potential large fires to a loss of only 795 acres of burned-over National Forest land.

An investigation was immediately initiated by the National Forest Criminal Investigator in cooperation with law enforcement agents of the Louisiana Forestry Commission. It was learned that a horseman had been observed deep in the "Piney Woods," and that numerous fire sets had been reported in the same area. A detailed search of these areas disclosed a fresh set of horse tracks,

Figure 2.—Remains of the slow-match found at one fire set. Note the fiber glass core, kitchen matches, and electrician tape.

Figure 3.—Fiber glass core of the "fuse" of another slow-match. The pen is 5½ inches long.

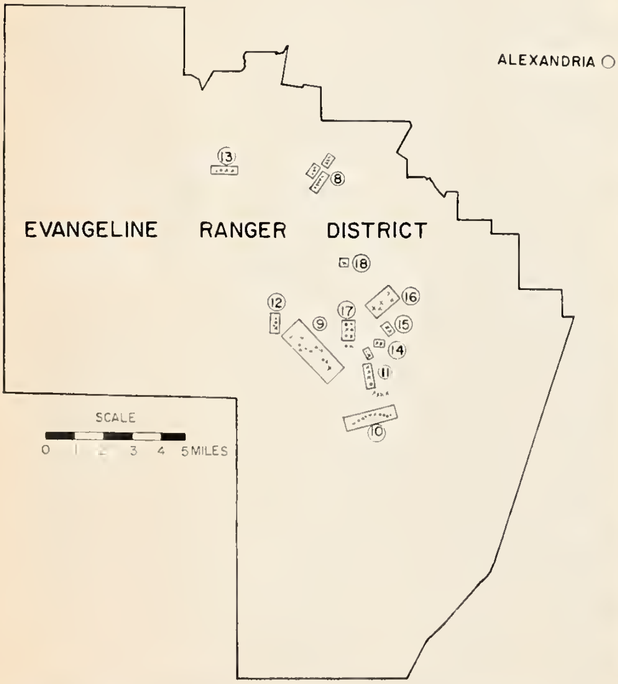

Figure 1.—Map of the Evangeline Ranger District. Each "X" denotes an incendiary set. The numbers indicate the District fire number.

and later the remains of the incendiary device—a slow-match—was found (fig. 2). Additional searching revealed what was subsequently identified as the core of the "fuse" of another slow-match (fig. 3).

By careful handling, these two fragile items of evidence were preserved and sent to the FBI laboratory in Washington for examination. The FBI reported that the slow-match was constructed of one-quarter-inch braided cotton cord, was cotton filled, and had strands of fiber glass as a center. Common kitchen matches were bound to the cord with one-half-inch electrician-type plastic tape. The other core that was found was identified as fiber glass of the same type used in the slow-match.

Field experiments with slow-matches (fig. 4) made from materials similar to that shown in figure 2 revealed that the cord burns at the rate of 1 inch per 12 minutes. It was determined that the incendiary device had a "fuse" cord of approximately 5 inches. Thus, the arsonist(s) had 1 hour to make their getaway from the area after dropping the slow-match in the forest litter.

Due to the unusual fiber glass core, it was believed that if the store selling this type of cord could be located, it might lead to the identity of the arsonist(s). Numerous inquiries were made at local outlets, but no rope or cord with this particular characteristic was found. These inquiries did, however, develop a list of wholesalers and cord manufacturers. Correspondence with 21 of these companies resulted in the receipt of many samples of cord. One sample, furnished by a Boston, Mass., manufacturer, appeared identical to the cord used to make the incendiary device. This cooperative company also furnished the identity of their wholesale outlet in the South.

Figure 4.—Sample of a slow-match before burning. The cord measures 5 inches from the end to the head of the matches.

More than 150 forest residents, local businessmen, law enforcement officers, and Forest Service employees have been interviewed. Stories and alibis have been checked, and more leads have developed. The store from which the arsonist(s) obtained their cord has not been located. The investigation is continuing, and it is hoped that the arsonist(s) will be identified and brought to justice through the medium of a piece of 6-inch cotton cord (with fiber glass core).

REWARD PROGRAM MADE STATEWIDE

From The Voice of Forestry
Mississippi Forestry Association,
Jackson, Miss.

As a positive step toward combating destructive forest fires, the Mississippi Forestry Association (MFA) has launched a statewide forest fire reward program, announced James M. Vardaman, Jackson, chairman of the MFA reward committee.

Vardaman said that tree farmers from all parts of the State have pledged a total of $10,000 to be used in offering a $500 reward in each county for information leading to the arrest and conviction of persons setting woods fires. The reward program was started last year, and by the end of the fire season 14 counties were participating. The effectiveness of the program led the MFA board of directors to make the project statewide.

Vardaman said that the MFA is working in close cooperation with the Mississippi Forestry Commission. In each county, personnel of the Commission are posting notices of the reward in public places and at the scene of burned forested areas.

Last year, according to the State Forestry Commission, Mississippi suffered nearly 9,000 forest fires which destroyed more than 90,000 acres at a loss of $3¼ million. Besides timber destroyed, this loss included a number of crops, fences, barns, and other buildings.

Unimog—*Continued from page 11*

Model 411.117. They have a four-wheel drive system. The front drive can be engaged while in motion without use of the clutch. The unit will operate at from 1 m.p.h. (for pulling a plow) to 40 m.p.h. (for use on the highway). A few details of the vehicle follow:

Cost, $5,200 (delivered on State bid).
Total dimensions, 70.5 inches wide, 151 inches long.
Wheelbase, 83.5 inches.
Tire size, 10 by 18.
Clearance under differential, 14.5 inches.
Engine, four-cylinder Mercedes-Benz diesel.
Workload capacity, 2,205 pounds.
Drawbar pull, 4,840 pounds.

As used by the Pennsylvania Forest Service, the units have proven quite versatile. They have, in addition to the fireline plow, been equipped with slip-on units consisting of a 120-gallon steel tank, a portable pump, and a live reel with 300 feet of three-fourth-inch hose. They have been used on fires as follows:

1. As a fireplow that can travel roads at 40 m.p.h., cross rough terrain, and plow firelines.

2. As a direct attack unit, applying water on the fire edge.

3. For scouting fires over terrain unsuitable for use of conventional vehicles.

4. For moving men, equipment, and food from road to fire over difficult terrain.

Figure 3.—Side view showing the plow in position ready for final lowering. In transit the plow is carried in the lift position, secured to the tailgate.

5. To support retardant warterdrops on incipient forest fires, made by water bombers, thus insuring early control and the loss of only small acreage.

In addition to on-fire jobs, the plow units have been used extensively to construct and maintain back lines for hazard-reduction burning in connection with railroad rights-of-way, dumps, hazardous residential and play areas, and similar areas that are prone to fire. Operating costs have been quite low.

No difficulty has resulted from damage to the pump unit from branches or other overhead hazards. However, the units have been used mostly in scrub oak and hardwood brush areas where this hazard is minimal.

Visible Area—*Continued from page 10*

the photo method is used with background lighting. The entire map may be floodlighted for a fast exposure (1/150 second) to faintly bring out the map detail where flashes have not illuminated it. The seen area is exactly where it belongs because the photo serves as the base map.

Results and Potential Uses

Comparison of the pictures (fig. 5) with seen-area charts made by the profile method indicated that the cost of the pictures was more than justified. With this method indications are that the discrepancy in area might be held to a maximum of 10 percent. Some hidden area near the point source is lightened by reflection error when flashing for extended coverage (fig. 6).

This method is convenient for showing combined coverage of several lookouts (fig. 7). Composite pictures were made with up to 17 lookouts by bringing the whole district area into camera focus, and flashing succeeding lookout pivots without changing film.

This method has not been tried for charting the seen area of an air patrol path, but it is possible that wire tracks can be mounted on the map to represent the course and height of the patrol plane, and that light can be moved along the wire for progressive exposures. Such a method might aid in determining course and altitude in flight plans.

WINDSPEED AND THE PROBABILITY OF FIRE OCCURRENCE

Ralph M. Nelson, *Research Forester,*
Southeastern Forest Experiment Station

An Ignition Index is one of the indexes proposed in the National Fire Danger Rating System. It is questionable whether or not windspeed should be included as a variable. Supposedly, the number of man-caused fires should increase with an increase in windspeed. To check this supposition, analyses were made of several protection units in the East and South (table 1).

The r^2 column in the table refers to the percentages of variance in fires per day that can be attributed to windspeed. The maximum variance was 11.2 percent in New Jersey's Division B. Although the true effect of windspeed was partly masked by unknown changes in risk, the measured effect in terms of percent of variance was not great, considering the range of windspeed in all of the six areas.

Table 1.—*Relation of windspeed to number of man-caused fires*

Area	Period		Days	Fires	Range in windspeed	r^2*
			No.	*No.*	*M.p.h.*	
Georgia, District 4	Jan.–Apr.	1961–63	94	1,221	2–19	0.010
Georgia, District 6	Jan.–Apr.	1961–63	133	401	0–19	.060
New Jersey, Division B	Mar.–Apr.	1959–63	109	912	4–20	.112
New Jersey, Division C	Mar.–Apr.	1959–63	109	1,161	4–29	.083
Rhode Island	Spring cured	1951–60	90	337	1–32	.021
Virginia, District 2	Mar.–Apr.	1959–63	113	1,112	2–21	.048

*r^2 = Coefficients of Determination = the percentage of variance in fire occurrence attributed to windspeed.

In order to minimize error resulting from variability in fuel moisture, only days having estimated fine fuel moistures of 6.5 percent or less were considered. Fuels were highly flammable on all these days. Depending on the area, different methods were used to calculate fuel moistures. These included use of basswood slats, measurement of air temperature and dewpoint, and determination of air temperature and wet-bulb depression.

Also depending on the area, windspeeds were taken from well-operated standard fire danger stations or from airport exposures corrected to a 20-foot standard.

It was impossible to eliminate the effect of risk—the activity of fire starters.

Thus, windspeed apparently had little effect on fire occurrence.

There was much scatter of points about regression lines for each area, but the slope was upward except for the two districts in Georgia. In District 6, the number of fires decreased as wind increased.

The reasons for the differences between protection units in New Jersey and Georgia are not clear. Perhaps the predominantly rural population in the Georgia areas, although careless at times with fires, is more aware of the danger in burning debris and in otherwise starting fires when windspeed is high.

Based on this analysis, windspeed would be a minor variable in an Ignition Index for the East and South and might well be omitted.

The article "The Forest Fires of April 1963 in New Jersey Point the Way to Better Protection and Management," *Fire Control Notes,* July 1964, contained an error. The first sentence of the final paragraph of page 4 should be: "More recent burns that left some surface fuel remaining only reduced the damage, but others that removed nearly all the fuel *did* stop the fire." The authors wish to make clear that relatively clean burns in the year before April 1963 stopped both strong head fires and flank fires, and enabled far better control by ground crews.

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WASHINGTON, D.C. 20250

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Vortex Turbulence—*Continued from page 6*

only two or three on forest fires. However, what is known about the vortex and about fire behavior can lead to some pretty good guesses.

Because wind tends to break up the vortex and is normally accompanied by much natural turbulence, the chances are that vortex turbulence will probably be noticeable only on a calm day. Not only will the vortex wake be stronger on quiet days, but because the fire will usually be spreading slowly, the sudden air turbulence will be even more unexpected and potentially serious.

On the ground, the effect of vortex turbulence will be felt as a sudden gust which may last only a few seconds or for up to half a minute. In litter, grass, or light brush the result will be a sudden but brief flareup or increase in local fire intensity and rate of spread. In heavy timber or brush fuels with a continuous overstory, vortex turbulence will usually not reach the ground and so will have no noticeable effect on fire behavior.

In patchy fuels, where timber or brush is interspersed with open grassy areas, the effects of vortex turbulence may be extremely serious. Although the vortex wake will not reach the ground beneath a timber canopy, it may in the openings. Because the core usually remains above ground, the true wind direction at the surface is not parallel to the ground but slightly upward (fig. 4). Thus both flames and burning embers tend to be swept upward as well as out. Thus vortex turbulence, compared with a natural gust of the same velocity, has a greater potential for triggering crowning and spot fires because flames and embers are driven up into the crowns.

The most serious situation is calm air on the ground but a light, steady wind aloft. Under these conditions the vortex may be carried far from the aircraft to strike the ground in an unexpected location, with ember showers being moved over long distances by the upper winds. Only rarely would one encounter a fire in patchy timber and brush under precisely these weather conditions; yet this was apparently the case on one well-documented fire in California in 1962.

Summary

Vortex turbulence consists of a pair of miniature whirlwinds trailing from the wingtips of any aircraft in flight. The more heavily loaded the aircraft, and the lower and slower it flies, the stronger the vortex turbulence will be and the more likely to reach the ground. The vortex will be in the form of a horizontal whirlwind with velocities up to 25 m.p.h.—sufficient to cause sudden and violent changes in fire behavior on calm days in patchy fuels.

Wind, gustiness, and surrounding high vegetation will tend to break up or diminish vortex intensity.

The fire crew should be alert for trouble when:

1. The air is still and calm.
2. The fire is burning in open brush or scattered timber.
3. The air tanker is large or heavily loaded.
4. The air tanker is flying low and slow.

The air tanker pilot should be aware of the problem his aircraft can cause. He may know the effect of vortex wakes on his or other aircraft, but may not know the effect on a fire. He can abide by the following rules during situations of possible danger from vortex wakes:

1. Don't fly parallel to the fireline more than necessary.
2. Keep high except when making the actual drop.
3. Ensure that ground crews are alert to the presence of the air tanker and the pilot's intentions.

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FIRE CONTROL NOTES

U.S. Department of Agriculture
Forest Service

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

CONTENTS

Please submit contributions through appropriate channels to Director, Division of Fire Control, Forest Service, U.S. Department of Agriculture, Washington, D.C. 20250. Articles should be typed in duplicate, double space, and with no paragraphs breaking over to the next page. Elite and pica copy should be 54 and 45 spaces wide, respectively.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and organization.

Authors are encouraged to include illustrations with their copy. Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints or India ink line drawings are acceptable. Captions for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the caption being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

When Forest Service photographs are submitted, the negative number should be indicated with the caption to aid in later identification of the illustrations. When pictures do not carry Forest Service numbers, the source of the picture should be given, so that the negative may be located if it is desired.

***Cover:* Native weather observer at Canyon Village, Alaska, aids fire control agencies by making observations in a remote area. See story on page 6.**

(NOTE—Use of trade names is for information purposes and does not imply endorsement by the U.S. Department of Agriculture.)

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CAN GLASS AND METAL CONTAINERS START FOREST FIRES?

D. M. Fuquay and R. G. Baughman, *Research Meteorologists, Northern Forest Fire Laboratory*

Most forest fires are related to the activities of man — industrial operations (milling, logging, and railroading), careless smoking, indifferent use of fire by the camper, and arson. Natural causes include lightning and spontaneous combustion. A few even have started by falling aircraft, rockets, and guided missiles. But are there less obvious causes of ignition in the forests?

Glass jugs and cans have been found at the source of forest and grass fires. Could these glass and metal containers start a forest fire by simply concentrating sunlight? The answer is definitely "yes" — but not in the manner most commonly supposed.

Broken kerosene and gasoline jugs occasionally found near the origin of forest fires have led to speculation that the volatile liquids were directly heated by the sun until gas pressure broke the container, and the liquid spontaneously ignited. This explanation is unsatisfactory because these volatile liquids cannot be heated to their autoignition point by direct sunlight. Besides, water jugs also are believed to have started fires. *However, another physical explanation is plausible: the capability of any transparent container, full or partially filled with a clear liquid, to form an optical lens and focus the sun's rays onto combustible materials.*

Forest fire researchers have long wondered whether containers could start forest fires. In 1946, Gisborne attempted to cause ignition in grass by scattering bottles and bits of broken glass in an open field. Apparently he was not successful. MacTavish (1960)[1] recently reported that a Canadian forest fire research party, after finding several exploded cans in burned areas, examined the ability of aerosol cans to ignite light fuels. The cans originally held ether for starting cold engines. The Canadians decided that the cans were not heated to the point of explosion by direct sunlight after they found they could ignite punky wood by reflecting sunlight from the shiny concave bottom of an aerosol can. However, Dempewolff (1964)[2] reports that aerosol containers, especially those for the new highly volatile ether engine-starting sprays, have exploded in closed automobiles under a hot sun, where temperatures readily soar above 150° F.

We repeated the Canadians' tests by igniting woody fuels with solar energy reflected from the bottoms of common aerosol cans. We also ignited various woody fuels and pine needles by using glass containers filled or partially filled with water to concentrate the sun's rays.

A can ignites a fire differently from the way a bottle does. The spherically concave bottoms of cans *reflect* and focus the sun's rays at a point near the center of curvature of the reflector (fig. 1). Nearly all cans can be bent or deformed to make a similar reflector. Light rays passing through a bottle containing a clear liquid are *bent* or *refracted* so that they focus beyond the bottle (fig. 2). The effect is similar to that produced by a common reading glass. Because of the compensating effect of refraction at the four air-glass interfaces, there is very little convergence of sunrays that pass through an empty glass container. To focus sunlight, a vessel must contain a reasonably clear liquid having an index of refraction approximately the same as its own. Water, kerosene, gasoline, and many other liquids meet this requirement.

Figure 1.—Concentration of sunlight by the bright concave bottom of an aerosol can.

[1] MacTavish, J. S. A new worry in forest fire control. Timber of Canada. June 1960.

[2] Dempewolff, Richard. Those handy aerosols can be dangerous. Popular Mechanics. March 1964.

Figure 2.—Sunlight concentrated on a tree trunk by a gallon jug filled with water.

We used aerosol cans to start fires by reflecting sunlight from the bottom of a can onto a piece of woody material about 1 inch away. Cans with shiny surfaces invariably started smoldering fires within a few seconds. The ignition capabilities of liquid-filled containers shown in figure 3 were examined by holding fuels near the focal point of the refracted light. The concentrated sunlight from some of the bottles caused ignition of dry pine needles within a few seconds. The needles smoked, but no open flames were observed between ignition and complete degeneration to ash. Cans and bottles both started smoldering fires in punky wood.

After determining that cans and bottles could start fires, we used the following laboratory method to determine the relative ability of each container to concentrate light rays. A collimated beam from a 16 mm. motion picture projecter simulated parallel light rays from the sun. A type B2M photocell measured the intensity of light falling on the container and the maximum intensity near the focal point. The relative intensity factor was defined as the ratio of the maximum refracted or reflected intensity to the incident intensity. The results are summarized in table 1.

The gallon jug (number 1) and aerosol cans (numbers 2 and 3) ignited pine needles in less than 10 seconds on a clear summer day. In sunlight passing through a Thermopane window in late October, bottles 1 and 4 and aerosol cans 2 and 3 ignited punky wood. The ignition ability should be much greater in direct summer sunlight. The ignition occurred whenever a container had a relative intensity ratio

Figure 3.—Bottles and aerosol cans tested for fire-starting capabilities.

TABLE 1.—*Relative intensity factor and ignition ability of containers*

Container[1]	Maximum relative intensity ratio (lab test)	Caused ignition in sunlight		
		Yes	No	Not sufficiently tested
1. Glass jug	28	X		
2. Pressure can (bright)	22	X		
3. Do	20	X		
4. Rose bowl	14	X		
5. Fish bowl	12			X
6. Pressure can (dull)	11		X	
7. Syrup bottle	7		X	
8. Do	6			X
9. Dressing bottle	6			X

[1] Container numbers refer to correspondingly numbered containers in figure 3.

greater than 14. A colored glass gallon jug and aerosol can with a dull concave surface (number 6) failed to ignite woody fuels in direct summer sunlight; the intensity ratio of this can was only about one-half that of a similar can with a shiny surface.

We concluded that aerosol containers and liquid-filled jugs and bottles can start fires in forest fuels by concentrating sunrays. When bottles or cans are found in burned areas. the fire may have been started by refraction or reflection of the sun's rays; rupture of containers is the result of fire. not the cause. The probability of any given glass jug or metal can starting a fire is almost impossible to predict because of the interaction of several factors: Container location and orientation. fuel distribution and condition. and weather.

Fires from these sources could be reduced by putting a dull finish on cans or by allowing only colored glass jugs in forested areas. One thing is certain — the absence of glass and metal containers from woods and grasslands would lessen the probability of fire occurrence.

A COMBINATION POCKET METER FOR WINDSPEED AND DIRECTION

GEORGE R. ELLIS, *Fire-Weather Forecaster, U.S. Weather Bureau, Los Angeles*

The Dwyer wind meter (fig. 1) can be easily attached to a small automobile-type compass so an observer can simultaneously determine windspeed and direction. The usual compass mounting arm assembly is replaced by a pair of metal clamps about 2 inches long. The clamps are bent inward and adjusted to hold the lower end of the meter snugly. Such a bracket can be made fairly easily from heavy-gage sheet aluminum.

Since the user of the Dwyer meter faces into the wind to obtain a maximum reading, the compass will indicate the magnetic direction from which the wind is blowing. The compass reading should be corrected for the magnetic declination of the local area. This reading is accurate enough for fire-weather observations.

This device is convenient for field use since it eliminates the necessity of taking out a pocket compass every time a wind-direction reading is needed. The combined instrument can be hung from a hook on the belt.

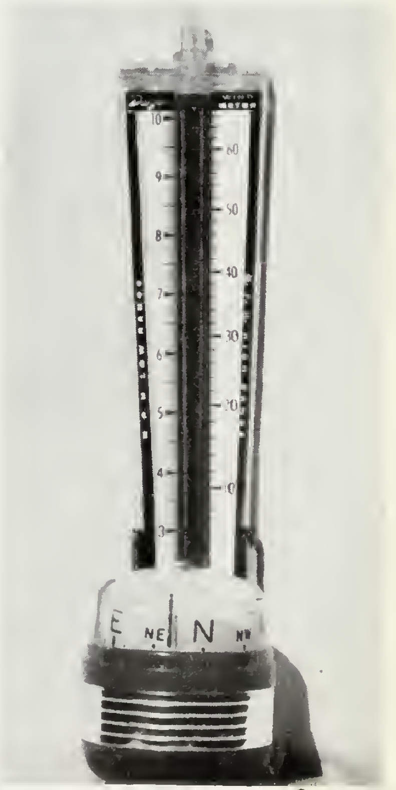

Figure 1.—The Dwyer wind meter attached to a small automobile-type compass.

SKY FIRE IN ALASKA — SUMMER 1964

F. D. PAXTON, *U.S. Weather Bureau, Anchorage, Alaska*
L. D. KING, *Bureau of Land Management, Anchorage, Alaska*

1964 Fire Season

Alaska had its lightest fire season on record in 1964. Only 160 fires occurred in a State with 225 million acres of forest, range, and tundra land to protect (fig. 1). The 65 fires caused by lightning burned just over 3.300 acres.

However, 1964 represented a potentially critical fire season because rainfall was below average for both June and July. The July 1964 average of only 0.99 inch created a highly volatile situation.

Figure 1.—Timbered southwest slopes, Brooks Range, Alaska (summer 1964).

Earlier Fire Seasons

In many previous years, millions of acres have burned. In 1957 the State suffered a burn of 5,340,554 acres. About 1 to 5½ million acres have burned at least seven times since 1940. Before records were kept, it can be conservatively estimated that an average of about 1 million acres burned each year.

Hardy and Franks[1] state that 80 percent of the forest lands in interior Alaska has burned during the past 70 years. An observer flying over this vast area can easily see the marks of recent and ancient burns. The areas burned and restored through time again become possible sites for extensive fires.

Alaskan Thunderstorms

The thunderstorm season in Alaska normally begins about May 1 and ends about October 1. Most Alaskan thunderstorms occur during the long summer days when interior areas become relatively warm and dry. Such prolonged heating is conducive to thunderstorm activity. These are "air mass" thunderstorms. Frontal, orographic, and squall line storms do occur in Alaska, but they are not as common or difficult to forecast.

Organization

New observation stations in remote areas were used during the 1964 summer season (fig. 2). Inhabitants of these areas were trained, and they proved to be diligent observers (fig. 3).

The fire-weather forecasting assistance provided by the Weather Bureau has already been beneficial to the fire control system of the Bureau of Land Management. Forecasting the occurrence of thunderstorms capable of creating lightning which cause fires, and forecasting surface winds and other weather conditions once a fire has begun are of prime importance in aerial inspection of potential fire sites and in fire control.

Working in the Bureau of Land Management communications center at Fairbanks, the Weather Bureau

[1] Hardy, Charles E., and Franks, James W. Forest Fires in Alaska. U.S. Forest Serv., Intermountain Forest and Range Expt. Sta. Res. Paper INT-5. 1963. 163 pp.

forecaster and Bureau of Land Management fire control personnel quickly became aware of the operational techniques of the other agency. To insure immediate consideration of pertinent weather information. two teletype circuits were installed. One provided a direct contact with major Bureau of Land Management fire stations and the Weather Bureau's main forecast office in Anchorage. The other provided aviation weather information from statewide Weather Bureau and other reporting units. Fire control personnel always had up-to-the-minute fire weather information and forecasts. This organization provided several important operational benefits. During the normal working day, field personnel needed only to establish radio contact to discuss weather conditions with a forecaster. During morning planning of patrol flights, the pilot. fire control personnel, and the forecaster were able to meet personally and analyze projected weather conditions. This saved invaluable flight hours and permitted an aircraft to be above the area of greatest fire potential on a given day. In addition. as weather conditions changed, it was only minutes before a patrol flight could be re-oriented to meet a new threat.

Figure 2.—Local observer at Kobuk, Alaska, measuring precipitation (summer 1964).

Figure 3.—Native observer at Canyon Village, Alaska (summer 1964).

Summary

We attribute much of our below normal burned area to good planning. Better communications, more observations. quicker on-site inspections, and more effective use of fire weather forecasts all were partly responsible. Planning for the 1965 season will be expanded and will include some more innovations.

50 YEARS OF FIRE WEATHER SERVICE

ALICE J. SVORCEK, *Secretary*
U.S. Weather Bureau
Missoula, Mont.

Introduction

The destructive 1910 forest fires in the Pacific Northwest made the public and fire protection people much more aware of the great need for improved protection. A key requirement was better information on weather.

In 1911, Congress passed the Weeks Act, which included a provision for Federal aid to forest protection groups. In the spring of 1913, the U.S. Forest Service and Western Forestry and Conservation Commission asked the Weather Bureau to begin a study of meteorological conditions conducive to conflagration in Washington and Oregon, and methods of forecasting these conditions. The Weather Bureau then arranged for additional weather reports from British Columbia. For the 1914 fire season a warning system was initiated for Washington, Oregon, Idaho, and California. Forecasts for Washington and Oregon were issued by the district forecaster at Portland, Oreg., and for Idaho and California by the district forecaster at San Francisco. These efforts marked the beginning of specific meteorological help to fire control agencies by the Weather Bureau.

Fire Weather Service: Formation and Growth

The Fire Weather Service was officially established as a separate forecasting service of the Weather Bureau on April 10, 1916. Forest areas where serious fires were likely to occur were studied, and a cooperative plan for providing weather reports from stations in these areas was initiated by Weather Bureau and Forest Service officials.

The West

Abnormally dry forests in California, Oregon, and Washington in early 1924 prompted emergency preparations for the fire season. The Forest Service and forestry associations of Washington and Oregon offered financial assistance to the Weather Bureau for the assignment of meteorologists to study weather conditions and to issue local forecasts. Meteorologists George W. Alexander and Charles I. Dague were the first fire weather forecasters assigned to Seattle, Wash., and Portland, respectively. California fire weather forecasts were issued by San Francisco District Forecaster E. H. Bowie. The first fire weather forecasts under the new arrangements were issued August 1, 1924.

Offices were established in the 1930's at Boise, Idaho, Missoula, Mont., and Mt. Shasta and Pasadena, Calif.; the Boise office was later moved to Spokane, Wash. During the 1940's the Boise office was reopened, and subdistrict offices were added at Pendleton, Oreg., and Olympia, Wash.

One great problem of the Fire Weather Service was sending the forecast and its interpretation to the firefighters in the field. The idea of using mobile units to provide on-the-fire weather information is credited to Leslie G. Gray. Gray, a fire weather meteorologist at San Francisco, assembled the first mobile unit in 1928, using a truck which he equipped with a two-way radio, meteorological instruments, and facilities for charting weather data. This original model was placed at Pasadena. He adapted four more large trucks for the Weather Bureau in 1936. These were placed at Missoula, Seattle, Portland, and Mount Shasta.

The East

The first organized fire weather warning service in the Eastern States began in 1924, in cooperation with the Connecticut State Forest Fire Warden. In 1925, service was extended to include the remaining New England States and the Adirondack section of northern New York. Forecasts were issued from New Haven for Connecticut and from Boston for the remainder of New England. Forecasts for the Adirondack region were issued from Albany, N.Y.

The South

Service in the South began in the winter of 1932-33. Forecasts were first issued from the Asheville, N.C., Weather Bureau office in the spring of 1933 for a limited area of the southern Appalachians.

New Plan Becomes Necessary

Several stations had integrated forecasting programs by the 1950's. The duties of fire weather men on these

stations were too varied to permit them to keep pace with growing fire control programs. A firm foundation and guide was needed for the Fire Weather Service.

1961 Plan for Fire-Weather Service Expansion

Early in 1961 a "National Plan for Fire-Weather Service" was jointly developed by the Weather Bureau and U.S. Forest Service in cooperation with other fire control agencies. The plan proposed more intensive service to meet the needs of all fire protection agencies, and it is gradually being implemented as funds are made available.

Adoption of this plan resulted in establishment of new fire-weather offices at Albuquerque, N. Mex., Phoenix, Ariz., Reno, Nev., Denver, Colo., Medford, Oreg., Wenatchee, Wash., and Fresno, Sacramento, and Eureka, Calif., in the West: St. Louis and Houghton Lake, Mich., in the Midwest; and Fort Smith, Ark., Raleigh, N.C., Jackson, Miss., Shreveport, La., and Montgomery, Ala., in the South; Beckley, W. Va., in the East: and Anchorage in Alaska. Staff additions have been made at 12 other offices.

Under the new National Plan, 18 mobile forecasting units were acquired late in 1961. These are camper units mounted on pickup trucks. Each camper is equipped with radio, facsimile, and modern meteorological instruments. Normally, one mobile unit is dispatched to each project fire. However, three of these units provided weather forecasts and information to several protection agencies at the huge Nevada brush fires in August 1964. In September 1964, four units gave up-to-the-minute weather information to fire bosses on the California fires.

To meet the prime objective of the National Plan — that of providing detailed advisories for fire control and forest management activities — several important tasks remain:

A. The Fire Weather Service needs a vigorous research program.
B. Communications must be improved in many areas to facilitate an exchange of information between fire control people and meteorologists in the field units and at base stations.
C. Operating plans and forecast formats need to be standardized.
D. The manpower to carry out the National Plan must be assigned to the fire program and trained in the specialized problems encountered by the fire weather meteorologist.

The National Fire Weather Plan provides a mutual charter for the Weather Bureau and fire control agencies, and when it is fully implemented it will greatly benefit the American people by saving money and resources.

NORTHWEST OREGON AND CYCLISTS REACH UNDERSTANDING

Adapted from THE FOREST LOG, *State of Oregon, Department of Forestry, Salem, Oreg., November 1964*

Motorcycles are a primary fire hazard when operated in dry forest fuels, and they aggravate soil erosion problems in steep terrain during the rainy season. They are of year-round concern to the forest land manager, and this activity is gaining popularity.

Increasing use by motorcyclists of the mountainous terrain in the Tillamook burn has resulted in the need for an agreement between local foresters of the State Forestry Department and the major motorized organizations utilizing the area. The presence of about 250 to 300 motorcyclists from the Portland-Beaverton-Gresham area and outlying points devoted to hill climbing, trail riding, and racing over the firebreaks and roads in the rough back country has necessitated the development of some ground rules.

A special system known as "Class of Riding Day" has been in operation for over a month with good results. Green, yellow, and red classes of riding days have been designated, with current conditions posted at Forest Grove, Tillamook, and Lee's Camp.

The green permits riders to travel throughout the burn on State forest lands except on dirt roads and steep firebreaks that are wet.

The yellow indicates restrictions on the use of certain areas of high fire hazard or excessive resistance to control of fire and requires the clamping of screen wire over the vehicle's exhaust outlets.

A red day means that no riding is permitted anywhere in the burn.

When the burn is covered by a permit closure, the cyclists are under the same obligation as the rest of the public to obtain an entry permit.

SOUTHERN FOREST FIRES: A SOCIAL CHALLENGE[1]

George R. Fahnestock, *Research Forester, Southern Forest Experiment Station*

The Problem

Annually, the 11 Southern States have half to four-fifths of the forest fires and roughly the same proportion of the area burned in the Nation, excluding Hawaii and Alaska. The 169,500 fires in 1950 were the most since World War II, and in 1947 a record 21 million acres burned. In 1957, the easiest year in history, 44,100 fires burned 2.2 million acres, 53 and 65 percent of the respective totals for the United States. Based on estimates, the South should supply 55 percent of the country's current and future timber demand (fig. 1). In 1952, a moderately bad year, fire losses were 5.8 billion board feet of sawtimber, equivalent to nearly a billion dollars' worth of finished wood products. In addition, fire destroyed 1.4 million cubic feet of growing stock — small trees representing much future productivity. The region's timber economy cannot tolerate such losses, and the productivity of forest land is greatly reduced.

More than 98 percent of the South's forest fires are caused by people, but the protection effort, including research, has been focused on the fires, not the people. Since the end of World War II the South has made great advances in fire control. About 90 percent of all forest land is now under organized protection (compared with less than 50 percent in 1945). Early detection and prompt attack using improved methods and machines have reduced the average fire size on protected land by one-half. But a downward trend in the rate of occurrence has not been apparent.

Figure 1.—Fire-damaged timber on the Osceola National Forest, Fla.

History

Fire always has been a factor in the development of southern forests. Before the coming of man, lightning caused occasional fires that spread over wide areas. Later the Indians used fire to drive game and to reduce the density of undergrowth.

Early white settlers in the South had to clear the forest and keep it in check; the easiest possible means was burning. They readily adopted the Indian method of burning unwanted brush to "green up the range" for domestic livestock. Indiscriminate burning was encouraged by low land and timber values, destructive timber exploitation followed by tax delinquency of cutover lands, absentee ownership of large blocks of land for mineral speculation, need for livestock range, and many other economic factors. The necessity for fire protection has increased with enlargement of the density of settlement, demand for a sustained yield of forest products, and use of the forest for recreation.

Research

In 1938, the Forest Service started an attempt to determine the roots of the fire-prevention problem through psycho-sociological studies in several areas with a high incidence of man-caused fires. Social scientists interviewed rural inhabitants and observed their folkways; some of the interviewers subsequently recommended fire-prevention practices. Today not many people are familiar with Kaufman's report on the Clark National Forest, Anderson's on the Deerlodge, Curtis's on the Cumberland, and Shea's summations of the three; Shea's separate report on the Talladega: or Weltner's studies of the Apalachicola, Kisatchie, Bienville, and DeSoto.

From the investigations he conducted or supervised, Shea, a psychologist, concluded that fire-setting was largely an expression of the social frustrations of an isolated rural population with low income. He emphasized the personal pleasure derived from starting fires or watching the woods burn. Shea suggested that the Forest Service obtain the confidence of the people by providing recreational outlets for their frustration.

Weltner, a sociologist, attributed incendiarism more

[1] Presented at the national meeting of the Rural Sociological Society, Washington, D.C., August 1962.

to disruption of the existing socio-economic structure. For example, he pointed out that in much of the rural South physical wealth and social leadership were measured in terms of the number of cows owned, and proper management of cattle was thought to require range burning. Therefore, the community leader with many cattle often was the leading woodsburner. Weltner recommended improving personal relations, communication, and general cooperation between protection agencies and the rural population.

Weltner's and Shea's work undoubtedly has influenced protection agencies and forest users, although Shea's major thesis was not acceptable to foresters.

The other investigators also indicated the many ways in which fire was related to the rural culture. In general, they concluded that fire entered and remained in the Southern rural culture largely for economic reasons, but that a complicated interplay of social and psychological forces brought about the present wide variety of uses of fire and attitudes toward it.

Prevention research ended when World War II started, and action has revived only recently. An exploratory study in Mississippi in 1958 and a more exhaustive one in Louisiana in 1961 have shown that the same factors are responsible for patterns of fire occurrence. The problem has changed little in nature or magnitude in 25 years.

The Job Ahead

The following major steps in fire prevention research must be taken. These steps are listed about in sequence, but two or more may be in progress concurrently.

Measure the physical problem. — Fire occurrence varies amazingly with location. For example, Grant Parish, La., averaged 180 fires per million acres annually from 1956 through 1960, while Livingston, an apparently similar piney-woods parish, had more than 2,400. Weather largely determines when fires will occur in a given location. A system of fire danger measurement is in effect South-wide and can be used to account for the weather variable in comparing fire occurrence rates between areas and periods of time. Forest type, soil, topography, population density, and other factors interact to influence geographic and chronological patterns and intensities of fire occurrence. The physical problem must be clearly defined before priorities for and the nature of further work can be decided (fig. 2).

Study the psycho-sociological problem. — State forest fire control chiefs have enumerated 37 types of people who start fires in 45 ways for 125 reasons. Although some of the separate entries in each of these categories probably could be grouped, additional distinctive entries could be found to take their places. One could almost conclude that fires in the South start in every possible way and for every conceivable reason. Of course, the situation is not that simple — or not that complicated, depending on how you look at it.

A distinctive characteristic of fire occurrence in the South is the large number of incendiary fires, i.e., those set on purpose to burn over the land of another. There are a wide variety of reasons; many of these are technically sound and would be acceptable if the individual obtained permission for setting the fire, chose the proper time to burn, and controlled the extent of the burned area.

The South, like other parts of the country, has many fires that are due to carelessness in various circumstances. The chief cause is debris burning, which includes such diverse activities as burning trash in the dooryard and discarding large piles of dead vegetation in clearing land. The burner does not intend to let the fires get away, but many do. The persistence of fires attributable to carelessness reflects considerably the same social factors that nurture incendiarism, notably a type and degree of public tolerance that makes the fire-setter hard to catch and even harder to convict.

Obviously, we need to understand the basic attitudes and practices of the people who start the fires. General knowledge on this score is pretty good, but it must be identified much more reliably with specific localities, population groups, and even individuals. It also will be necessary to understand the broader implications of public opinion, the ambient climate that tells whether sympathy will be for or against the fire-setter.

Find out what constitutes effective influence. — How can people be persuaded to exchange old practices for new ones? Specifically, how can the fire-setters be made law abiding; the careless, more heedful; the irresponsible, more cognizant of values and the rights of others? Largely, we don't know how to communicate with our worst fire risks, that is, how to speak their language.

Once communication is established, the problem is to motivate. Research must find out what incentives will be most productive of the desired results. The

Figure 2.—Firelighters build a fireline on the Cherokee National Forest, Tenn.

advertising industry annually contributes invaluable knowledge and services to promote fire prevention through mass propaganda. Perhaps as pertinent in the South, however, are the sociologists' findings concerning the acceptance of new agricultural practices. The so-called "diffusion process" should work with firesetters, once effective motivation is discovered.

Fire prevention undoubtedly faces a major obstacle in that the impetus still comes from protection agencies rather than from the people of the grassroots. Badly needed is a means of enlisting the general public in active opposition to uncontrolled fire. Effectiveness of existing methods and media must be analyzed and evaluated impartially. The goal is the challenging one of learning how to persuade people to act for their own good in the face of indifference and of contrary, cherished customs (fig. 3, p. 16).

Design prevention systems.—The prevention studies of the late 1930's and early 1940's stopped with the writing of recommendations. A coordinated prevention effort embodying the new ideas did not develop, although sporadic beneficial changes in policy and practice did occur. Future research on fire prevention must offer a bridge for the gap between factfinding and action. This means participation in all phases of system design, including determination of priorities, establishment of goals, selection of techniques (also development of new ones), and assignment of responsibility.

Research and action agencies must cooperate closely. And from this need to cooperate arises another problem for the social scientist — some foresters do not realize that they need special techniques for dealing with people just as they do in accomplishing the physical jobs of forest management. More than one otherwise progressive forester has opposed fire prevention research on the grounds that we already have the know-how and need only apply it.

(Continued on page 16)

LIQUID PHOSPHATE FIRE RETARDANT CONCENTRATES

R. W. JOHANSEN[1] and G. L. CROW[2]

Introduction

Fire control organizations and suppression methods used to combat forest fires in the Southeast have improved rapidly since the time when only handtools and pine boughs were used. Most wildfires can now be successfully combatted by using current detection methods and tractor-plow units and ground tankers. But the few fires that become large account for most of the area burned. In Georgia, during 1954-56, 1 percent of the fires accounted for more than 90 percent of the area burned.[3]

The best method of preventing conflagrations is to suppress fires while they are small. This requires early detection and quick, effective control action. About a decade ago, Operation Firestop proved that the use of aircraft could appreciably increase area accessibility, and thereby reduce the time between detection and an early, adequate attack.

Early Retardants

The first retardant used in air tankers was sodium calcium borate. However, in 1959, tests in Georgia showed conclusively that ammonium phosphate solutions were superior to borate on the fine forest fuels in the Coastal Plains.[4] Later studies in California indicated that thickened diammonium phosphate (DAP) solutions performed satisfactorily on western fuels.[5]

Initially, solutions of diammonium phosphate were of a 15 to 18 percent concentration (about 8 percent P_2O_5) made from dry salt crystals. Their use required physical handling of the salt, as well as mixing tanks and pumps for recirculating and transferring the liquid from the mixing container to an air tanker or holding tank.

[1] Research forester, Southern Forest Fire Lab., Southeast. Forest Expt. Sta., U.S. Forest Serv., Macon, Ga.

[2] Metallurgical engineer, Tennessee Valley Authority, Wilson Dam, Ala.

[3] Davis, Kenneth P. Forest fire control problems and research needs in Georgia. Ga. Forest Comm. and Southeast. Forest Expt. Sta. 1957.

[4] Johansen, R. W. Monoammonium phosphate shows promise in fire retardant trials. U.S. Forest Serv., Southeast. Forest Expt. Sta. Res. Note 137. 1959.

[5] Dibble, Dean L. Roadside hazard reduction with fire retardant chemicals. U.S. Forest Serv. Pacific Southwest Forest and Range Expt. Sta. Res. Note PSW-N-21. 1963.

Liquid Phosphate Concentrates

In 1961 representatives of the U.S. Forest Service met with Tennessee Valley Authority personnel at Wilsom Dam, Ala., and discussed the possible use of liquid phosphate concentrates in lieu of the dry salt. Preliminary evaluations at the Southern Forest Fire Laboratory indicated that retardant solutions made from liquid phosphate concentrate are about as effective as those made from DAP salt. These evaluations have been substantiated by operational trials in the South.

In 1962 the Forest Service contracted for air tankers on a trial basis in the southern Appalachians. A liquid ammonium phosphate fertilizer (11-37-0 grade), manufactured by the Tennessee Valley Authority from ammonia and superphosphoric acid,[6] was used as the base retardant. The correct quantity of this liquid concentrate was metered directly into the aircraft, and then water was added for dilution to the desired concentration of 8 percent P_2O_5. Except for pumping the liquid, agitation was not required, and most of the manual handling was eliminated. In addition, the trial drops made on wildfires met with undisputed success.[7,8]

Composition of concentrate

The phosphate in the liquid concentrate being manufactured by the Tennessee Valley Authority at Wilson Dam, Ala., is present as ortho- and polyphosphates in about the following percentages.

Pyrophosphate, 49
Orthophosphate, 28
Tripolyphosphate, 17
Other (mainly tetrapolyphosphate), 6

This material has a fertilizer designation of 11-37-0 and sometimes is referred to as "Pyro." When one part by volume of concentrate is mixed with five parts of water, the $N-P_2O_5-K_2O$ percent is about 2.4-8-0 and the solution has a phosphate equivalent (P_2O_5) of 8 percent. This phosphate equivalent is the same as that in a 15-percent DAP solution prepared from dry

[6] Slack, A.V., and Scott, W.C. Developments in high analysis liquid fertilizers. Commercial Fert. 105, 24–26, November 1962.

[7] Spring, John B. The southern Appalachian air tanker project. South. Lumberman 205(2561): 166. 1962.

[8] Spring, John B. Chemical retardants in fire control. Forest Farmer 23(5): 6–7. 1964.

salt, which has an $N\text{-}P_2O_5\text{-}K_2O$ percent of 3.2-8-0. Both provide successful results when applied on forest fuels in the Southeastern States.

Other available concentrate forms are designated as 10-34-0 and 8-24-0. The 10-34-0 is produced commercially from ammonia and wet process superphosphoric acid, and the 8-24-0 from ammonia and ortho-(regular) phosphoric acid. To obtain an 8 percent phosphate equivalent solution with 10-34-0 and 8-24-0, 1 gallon of concentrate would be mixed with 4.45 and 2.5 gallons of water, respectively.

The amount of salt that ultimately adheres to a forest fuel can be partially controlled in two ways: (1) the solution concentration can be altered by regulating the amount of salt per unit volume of water, or (2) the solution viscosity can be increased, resulting in a buildup of film thickness on forest fuels. In certain instances, i.e., when heavy litter fuels are treated, use of unthickened solutions or those with reduced surface tension may be necessary to obtain adequate penetration. The amount of salt adhering to any aerial fuel, however, would be maximized by treatment with a saturated solution thickened with a compatible thickener to the highest viscosity that would still disperse evenly when dropped from an air tanker or pumped from ground equipment.

Thickening and coloring phosphate solutions

Thickened mixtures are desirable for increasing salt retention on fuels and for carrying color. A mixing tank or an eductor in a pressurized waterline can be used to mix certain industrial gum or clay thickeners in any of the phosphate solutions. The final viscosity increase is frequently influenced by the form of parent material used to make the phosphate solution, as well as by the thickening agent (table 1). When mixed with Keltex FF and CMC-7HS, an 8 percent phosphate equivalent solution made from 11-37-0 concentrate will thicken less than one made from dry diammonium phosphate (DAP) salt. In contrast, Ja*guar* 307 and Polysaccharide B-1459 developed higher viscosities in solutions made from 11-37-0 than those made from DAP. When bentonitic or attapulgus clays are used as thickeners, the salt form used to make the retardant solution has no effect on the final viscosity.

Attempts have been made to add a thickening agent at the source of manufacture that would yield viscosities adequate for covering heavy fuels even after the concentrate has been diluted 5:1. This procedure would eliminate the need for mixing tanks or eductors at the loading station. Unfortunately, experimentation has not been successful.

If color is desirable in the solutions, the necessary ingredients can be added to the concentrate during manufacturing. Recommendations for each 40 gallons of concentrate are 15 pounds of Attagel No. 30, 1 pound of ferric oxide, and one-half pound of Rhodamine "B" concentrate dye. When diluted 5:1 in the field, enough color strength remains so that drop or spray patterns are visible.

TABLE 1.—*Viscosities of thickened 8 percent phosphate equivalent solutions made from DAP and 11-37-0 concentrate*

Thickener	Cost	Concentration	Viscosity[1] DAP 6 r.p.m.	Viscosity[1] DAP 60 r.p.m.	Viscosity[1] 11-37-0 6 r.p.m.	Viscosity[1] 11-37-0 60 r.p.m.
	Per pound	*Percent*	*Centipoises*[2]	*Centipoises*[2]	*Centipoises*	*Centipoises*
Keltex FF	$1.20	1	950	760	500	442
CMC-7HS	.60	1	700	470	250	180
Jaguar 307	.55	1	1,800	850	2,487	1,060
Polysaccharide B-1459	1.75	.5	3,400	540	5,300	940
Bentonite (Volclay No. 90)	.014	2	2,250	105	2,250	105
Attapulgite (Attagel No. 30)	.014	2	1,500	300	1,500	300

[1] Viscosity is a measure of the resistance of a liquid to flow or shear. The 6 and 60 r.p.m. values denote the turning rates of a spindle on a Brookfield viscometer. Differences in viscosity between the two speeds are due to differences in the reaction of the liquids to shear.

[2] Centipoise is a unit of viscosity measurement. Water and SAE 30 oil at 70° F. have values of 1 and 250 centipoises, at 6 and 60 r.p.m., respectively. The viscosity of these liquids is unaffected by differential shear.

Corrosion problems

The 11-37-0 liquid phosphate concentrate and the 8 percent phosphate solution used operationally are not excessively corrosive to mild steel or aluminum-base alloys under normal conditions of storage and use (unaerated solutions up to 80-90° F.). The concentrate usually is stored in mild steel tanks, and the tanks in aircraft carrying the retardant solution usually are aluminum. Tests made by the Tennessee Valley Authority (table 2) show that the corrosion rate of mild steel by the concentrate is only 3 to 6 mils per year, and that the rate of three aluminum-based alloys is 16 to 20 mils per year. However, with 0.1 weight-percent of sodium dichromate inhibitor in the retardant solution, the corrosion rates of two of the three aluminum alloys were only about 4 mils per year.

Because of this indicated improvement, the 11-37-0 concentrate is supplied containing 0.41 percent sodium dichromate so that the 8 percent solution will contain about 0.1 percent.

Neither the concentrate nor the solution was corrosive to copper-base alloys. Both were corrosive to magnesium alloys, however, and sodium dichromate was not an effective inhibitor.[9] This is not considered serious because (1) there is no reason for the concentrate to be in contact with aircraft parts and (2) the retardant solution may be in contact with aircraft parts outside the aluminum tank for only a very short time as the result of spray when the load is dropped. The short exposure time and the usual procedure of thoroughly washing the aircraft after each day of use minimizes the corrosion problem.

Summary

Liquid phosphate concentrates can be used advantageously in making fire retardant solutions, especially at permanent air tanker loading installations. At a cost of approximately 6 cents per gallon, f.o.b. producer, for an 8 percent phosphate equivalent solution, this retardant mix is slightly cheaper than those prepared from most dry salts. The greatest advantage of the liquid concentrate is the ease with which it can be handled. Other advantages include less need for storage space and mixing tanks, and excellent stability. Where the need for a viscous retardant solution exists, the advantages of using liquid concentrates are diminished.

[9] To prevent skin irritations, sodium dichromate corrosion inhibitors should not be permitted to contact the skin.

TABLE 2.—*Corrosion tests of alloys in 11-37-0 concentrate and 8 percent phosphate solution made from it*

Alloy	Corrosion rate at 80° F., unaerated		
	11-37-0 concentrate without inhibitor	2.4–8–0 solution made from 11–37–0 concentrate: Without inhibitor	2.4–8–0 solution made from 11–37–0 concentrate: With 0.1 percent sodium dichromate inhibitor
	Mils/year	*Mils/year*	*Mils/year*
Aluminum base			
A.S.A. 1100-H14	16	17	4
A.S.A. 2024-T3	18	26	29
A.S.A. 5154-H32	20	23	3
Copper base:			
Copper, deoxidized	< 1	< 1	—
Brass, red, A.S.T.M. B-36-61, alloy No. 3	< 1	< 1	—
Bronze, silicon, Herculoy 418	< 1	< 1	—
Bronze bearing, 80-10-10	< 1	< 1	—
Magnesium base:			
A.S.T.M. B94-58, die casting AZ91A	193	63	40
A.S.T.M. B91-60, forging, AZ31B-H23	237	42	45
Steel:			
A.S.T.M. A-285	6	8	1
A.I.S.I. C1042	3	13	1

The only thickener tested that is compatible with the 11-37-0 concentrate is attapulgus clay. The amount of clay added should not exceed 6 weight-percent in order to keep the concentrate viscosity at a pumpable level. The resultant solution, when five parts of water have been added, has a viscosity of less than 200 centipoises. Generally, higher viscosities are preferred when thickened retardant solutions are needed. Although none of the dyes or pigments tried could be

(Continued on page 16)

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FIRE RETARDANT CONCENTRATES
—Continued from page 15

dissolved or suspended in the undiluted 11-37-0 concentrate alone, coloring materials can be dispersed if attapulgus clay is also added to the mixture.

Liquid phosphate concentrates offer many advantages and no serious disadvantages when compared with dry salt, and fire control personnel should seriously consider their use. Further refinements with thickeners and coloring agents may make the use of liquid concentrates even more flexible.

SOUTHERN FOREST FIRES—Continued from page 12

Activate the prevention program.— This is the job of the protection agency, but research properly has a big stake in it. The first operations should be jointly sponsored pilot studies; the full-scale programs should follow. But the research job does not end here. The researcher and administrator must continue to collaborate for their mutual benefit: the former learns how his ideas are working out and obtains ideas for further research; the latter gets his questions answered and contributes valuable information on practical aspects of the job.

Finally research must continue because conditions and people change. Population pressure on forests for outdoor recreation will be an increasingly potent influence on fire and other problems. So, although the goal of fire prevention research is to put itself out of business, it looks as if it will have plenty to do for a long time.

Preplanned escape measures might save up to 85 percent of all lives lost in home fires, National Fire Protection Association studies show.

Figure 3.—Cooperative forest fire prevention material used in the Southern campaign.

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FIRE CONTROL NOTES

U.S. Department of Agriculture
Forest Service

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

CONTENTS

***Cover*—Infrared imagery of the Gilkinson Fire, Wallowa-Whitman National Forest, Oreg., at 8 p.m., July 22, 1963. Aircraft was 8,000 feet above terrain. This imagery is transferred to aerial photos and maps to give fire bosses up-to-date information on fire perimeter, spot fires, and hot spots. See story on page 3.**

(NOTE—Use of trade names is for information purposes and does not imply endorsement by the U.S. Department of Agriculture.)

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INFRARED—A NEW APPROACH TO WILDFIRE MAPPING

Robert L. Bjornsen, *Forester, Northern Forest Fire Laboratory, Intermountain Forest and Range Experiment Station*

Introduction

For campaign fires, accurate and quick intelligence is needed on the location of fire perimeters and spot fires. The fire boss and his staff need this knowledge to effectively maneuver manpower, equipment, and logistical support—particularly during critical fire periods. Airborne infrared fire mapping may provide a major advance in fire intelligence.

For 3 years, personnel of Project Fire Scan, a special program of the Northern Forest Fire Laboratory, have been testing an airborne infrared scanner. The U.S. Department of Defense is cooperating in the program, and the Electronic Command, U.S. Army Material Command has supplied the infrared equipment used in a Forest Service aircraft. Because results may significantly affect civil defense, the Office of Civil Defense is providing financial assistance and technical consultation.

Airborne Infrared Mapping

Individual sorties are scheduled so the fire boss will have optimum information. As the aircraft flies over the fire area, the scanner picks up the infrared energy emanating from hot burning fuels and surrounding terrain. The energy is converted to an electrical signal that is subsequently amplified by special electronics and re-converted to a visible light signal displayed on a cathode ray tube. Polaroid photographs of the cathode ray tube are then made. The resulting thermal imagery provides clear detail of the fire perimeter, hot spots, small fires outside the main fire perimeter, and terrain features.

When a sortie is completed, the infrared imagery is placed in a plastic tube and dropped to an imagery interpreter at fire headquarters. Perimeter and spot fire intelligence is then transferred to aerial photos and maps of the fire area. The average time from the start of a sortie until intelligence is transferred to maps is 2 hours—1¼ hours of flying time plus three-fourths of an hour for interpretation of the imagery. This interval will be reduced when operational scanners can produce better imagery in less time.

Program Accomplishments

Twenty-three wildfires, ranging from a few acres to many thousand acres, were mapped by the Project Fire Scan infrared scanner during 1962, 1963, and 1964. Fuel types varied from grass in Nevada through brush in California to mature coniferous timber in Montana. Character and control status progressed from uncontrolled spotting fires to creeping fires in the late stages of mopup. Because of dense smoke, instrument flying was often required, and much useful imagery was also obtained during darkness. Figures 1 and 2 compare results obtained from normal aerial photography with those provided by use of the infrared technique.

Figure 1.—Conventional oblique aerial photograph, Coyote Fire, Los Padres National Forest, Calif.

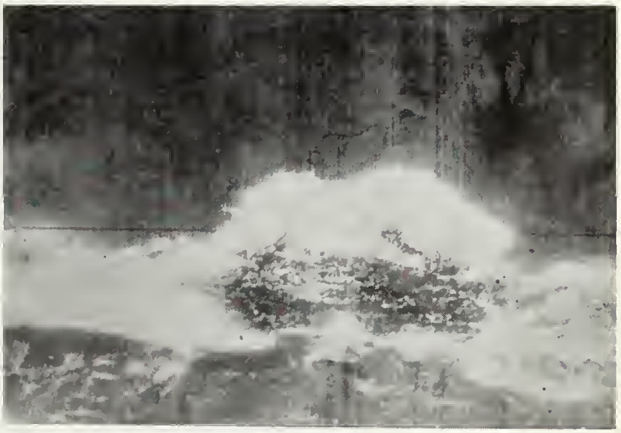

Figure 2.—Infrared thermal imagery through heavy smoke, Coyote Fire, Los Padres National Forest, Calif.

Improved Scanner

The experimental infrared scanner used does not meet requirements for size, weight, angular resolution, reliability, and imagery quality. A prototype scanner designed specifically for airborne infrared fire mapping will satisfy these requisites. Performance tests on the new scanner will probably be completed by midsummer 1965. Analysis of the fire-mapping capability of this scanner will be the basis for preparation of production model specifications. This scanner may be available for purchase and use during fire season 1966.

Capabilities and Limitations

Recognition of the capabilities and limitations of infrared scanning is a necessary prerequisite to effective use of the scanner as a fire-mapping tool. Use of infrared fire mapping permits the following:

1. Mapping of fires day or night.
2. Mapping of fires through dense smoke and smog.
3. Rapid surveillance during critical periods.
4. Accurate plotting of fire perimeter and spot fires.
5. Prompt determination of rate of spread.
6. Under smoky or nighttime conditions, determination of physical changes made by man since the last aerial photos were taken.
7. Perimeter intensity intelligence for efficient deployment of mopup forces.

The major limitations of infrared fire mapping are few, but important:

1. Infrared energy does not penetrate solid matter, cloud cover, or fog.
2. Few specially trained infrared imagery interpreters are available.
3. As with any airborne reconnaissance, extensive smoke pall from large fires can create aircraft navigational problems.

Conclusions

Test flights have demonstrated that campaign fire intelligence requirements can be met rapidly and accurately with airborne infrared scanners. Among other benefits, fire perimeter and spot fire intelligence from airborne infrared scanning will remove one of the fire boss's greatest problems, i.e., knowledge of the fire's location, particularly after a blowup has occurred. Airborne infrared scanning cannot solve all fire intelligence problems, but it is intended to supplement normal ground and air reconnaissance.

INFRARED FIRE DETECTION

Airborne infrared scanners also have shown great potential for fire detection. However, before this potential can be exploited, research must answer many questions about the relationships between detection probability, fire size, view angle, and vegetation characteristics. A major effort in fire detection research at the Northern Forest Fire Laboratory is directed toward these problems.*

*Hirsch, Stanley N. Infrared as a fire control tool. West. Forestry and Conserv. Assoc., West. Forest Fire Res. Council Proc.: 5-10. 1962.

CANADIAN INFRARED SCANNER

Canadian Department of Forestry,
Ottawa, Canada

An infrared scanner that may greatly improve forest fire detection in Canada will be tested this summer in the Ottawa area.

The scanner will be carried on regular fire patrol flights by aircraft of the Quebec and Ontario Departments of Lands and Forests. From mid-June through mid-August, the scanner will be flown by an aircraft of Quebec's Forest Protection Service. For the next 2 months of the fire season, the device will be carried on an aircraft of the Ontario Forest Protection Branch. The project is being co-ordinated by the Federal Department of Forestry.

Small fires may be pinpointed before they can be seen. The scanner is designed to record very slight differences in ground temperature on the terrain being scanned. These variations will activate a light signal or sound signal, or both, within the aircraft. The scanner also will produce a continuous thermal photograph or map of the terrain, permanently recording the precise location of hot spots.

A NEW EXPERIMENTAL FIRE AREA IN SOUTHERN CALIFORNIA

JOHN D. DELL, *Fire Research Technician, Riverside Forest Fire Laboratory, Pacific Southwest Forest & Range Experiment Station*

Forest fire research gained a new outdoor laboratory with the recent transfer of 13,000 acres of southern California chaparral from the Bureau of Land Management to the Forest Service. This site, known as the North Mountain Experimental Area, is in the San Jacinto Mountains. It is administered from the forest fire laboratory in Riverside, and is connected to the laboratory by roads open yearlong (fig. 1).

Site and Facilities

North Mountain is typical chaparral brushland. Elevations range from 1,500 to 4,357 feet. Three extensive drainages divide the area into a complexity of terrain representative of much of southern California's mountainous fire hazard areas.

The area will provide a site for testing materials, conducting demonstrations, and training firefighters. Seven hundred acres has been allocated as a testing site for the Forest Service Equipment Development Center at Arcadia, and 1,200 acres will be used for training firefighters. A small, functional administrative site, including a shop and warehouse, will be developed to facilitate and service projects. Additional access roads have been proposed for prospective study areas. A network of heliports and helispots will provide additional accessibility to the area, both for protection and research. The area can be used for cooperative research by other Federal agencies, by State and local fire organizations, and by university research groups. Research will not be limited to local problems; general fire control knowledge will also be sought.

Fuel-Break Construction

Since 1954, the California Division of Forestry has intensely treated land at North Mountain. Large areas of dense, highly flammable brush have been broken up by a network of strategically placed fuel breaks (fig. 2). These are wide strips of land from which heavy fuels were removed and replaced with lighter cover that offers less resistance to fire control (fig. 3). Nearly all of these fuel breaks are accessible via a well-planned road system.

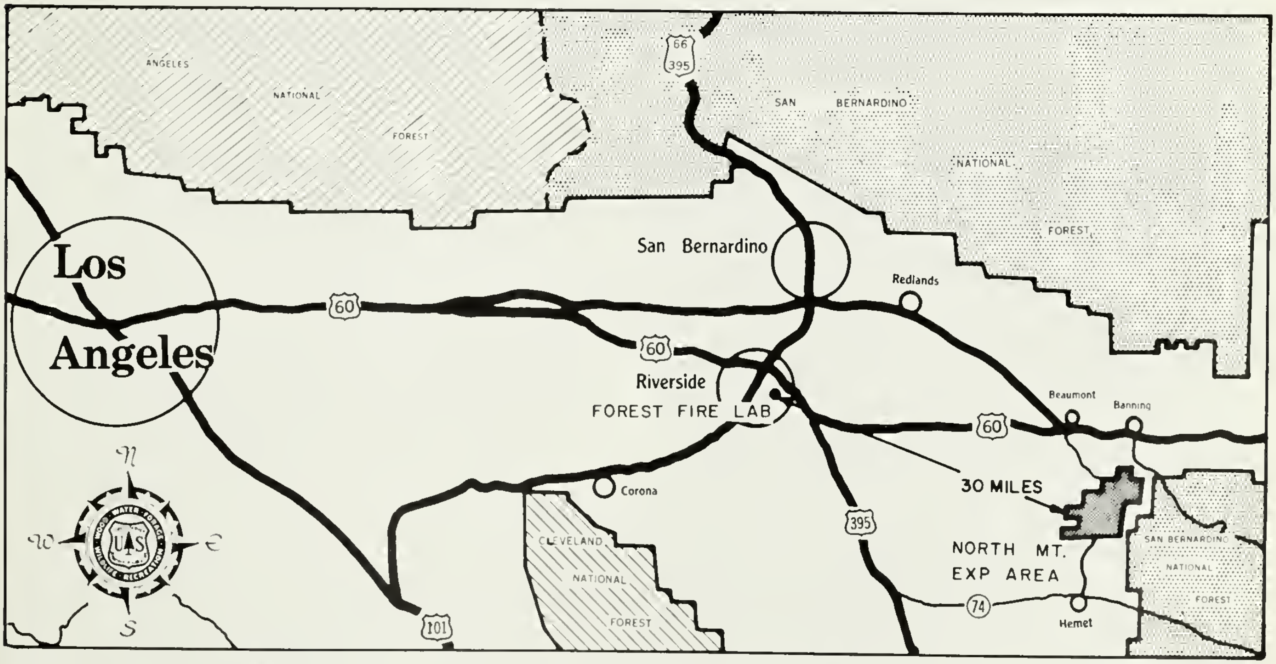

Figure 1.—The North Mountain Experimental Area is in the San Jacinto Mountains 30 miles from the forest fire laboratory in Riverside.

Figure 2.—Aerial view of a portion of the Experimental Area showing part of the extensive fuel-break system constructed by the California Division of Forestry.

Area's Fire Protection

Fire protection for the experimental area is provided by employees of the Riverside County unit of the California Division of Forestry, with nearby San Bernardino National Forest personnel assisting in a mutual aid zone. Within a 10-mile radius there are two Division of Forestry district headquarters and a county road camp. These units have up to 100 trained men available for firefighting. Three Forest Service fire stations are on the adjacent San Jacinto Ranger District. A new Forest Service lookout on Black Mountain covers North Mountain. The Ryan Field Air Attack Base in Hemet is only minutes away, permitting fast attack by air tankers if needed.

Figure 3.—A North Mountain fuel break on a ridgetop. This break is 300 feet wide.

New and Future Studies

Forest Service research started at North Mountain in 1964.

The extensive fuel-break system at North Mountain provides researchers with opportunity for such studies as the joint research project recently begun with the Agronomy Department of the University of California at Riverside. Researchers are investigating effects of herbicides and chemicals on certain brush species, adjacent soils, and seedling and sprout growth. Also to be studied are the physiological conditions

affecting shrub resprouting and the effect of soil moisture management on the establishment of woody and herbaceous seedlings.

Other parts of the broad program of developing chemicals and techniques to control sprouting brush include a planned scrub oak control study and additional studies involving fuel-break sterilants.

A seed production and storage study will attempt to find the seed yield of chaparral species and determine how long seed will maintain viability in the soil. This study will also investigate the effects of fire on seeds.

Fire behavior specialists are conducting fuel volume studies. These studies represent an attempt to determine principles and methods of fuel measurement which may serve as a basis for a comprehensive fuel survey and classification system. Some areas at North Mountain will be allocated for test burn plots for fire environment studies.

Studies of live and dead brush fuel moistures may soon provide important knowledge on forest fire behavior in chaparral. Diurnal fuel moisture variations in chamise and other flammable species are being studied during critical fire danger periods.

Meteorologists from the Forest Fire Laboratory are learning more about fire weather and are testing new instruments and equipment. Recently they studied the valley wind convergence zone in the Wolfskill Canyon Area to determine some of the mechanisms that produce down-canyon afternoon winds (fig. 4). Personnel from the U.S. Weather Bureau and California Division of Forestry assisted.

Researchers from the Engineering Department at the University of California at Los Angeles and from the Forest Fire Laboratory are examining the feasibility of using waste water from local valley communities to supply nearby mountain areas with scarce water for fire control and for green fuel-break irrigation. North Mountain may be used as a pilot study area for such a project.

Summary

This area provides forest fire researchers with their own field laboratory. Here research projects may be undertaken, studied, and analyzed without conflicting with other land management uses. The new North Mountain Experimental Area and the Forest Fire Laboratory at Riverside should provide a highly effective combination for improving our knowledge of fire and its control.

Figure 4.—Meteorologists studying fire weather at North Mountain.

PREVENTION OF FIRE CAUSED BY ELECTRIC FENCERS IN WASHINGTON STATE

Loren A. Tucker, *Supervisor, Fire Control Division,*
Department of Natural Resources, State of Washington

Electric fence controllers should control livestock but not set fires. Some fencers have a self-maintaining feature—they burn off the weeds that grow up around the wire so the farmer does not have to mow them.

In 1964, Washington's Department of Natural Resources analyzed the State's fire reports of miscellaneous cause and determined that self-maintaining electric fencers were starting an alarming number of fires. A recheck of fire reports indicated that all fires set by fencers were started by a type which the Underwriters' Laboratories would not approve. The Underwriters has certified several makes of fencers as fire safe but has never put its label on the weed burner models.

The Department's Fire Control Division began to attack this fire source. On June 2, 1964, the Board of Natural Resources promulgated Resolution 54. It declared that fencers which had not been certified by the Underwriters' Laboratories as fire safe could not be sold without a bright red warning label. The label, which is furnished to dealers by the Department, contained the statement seen in figure 1.

Since the label warns the prospective purchaser that he can use the uncertified fencer for only 5 months. the Department believes the weed burner controller will no longer be popular.

The Washington State Department of Labor and Industries has agreed to join with the Department of Natural Resources in the enforcement job. Department of Natural Resources men have contacted every known outlet of fencers in the State and have distributed about 15,800 labels.

The Underwriters' Laboratories has cooperated with the Department of Natural Resources splendidly and is prompt in notifying the Department as soon as another fencer is certified. There are many approved "certified fencers" on the Underwriters' lists.

Results of this prevention effort will not be available until at least one above normal fire season passes. However, the reactions of those affected by the Resolution indicate that the required results will be obtained.

Figure 1.—Uncertified fencer bearing Washington Department of Natural Resources warning label.

EXPERIMENTAL PARADROP OF TRACKED PERSONNEL CARRIER FOR USE ON INACCESSIBLE FIRES

James W. Thurston, *Anchorage Fire District Supervisor, Bureau of Land Management, Alaska*

Introduction

Helicopters often have been used around the perimeters of large fires in the remote portions of interior Alaska. Because they are expensive to operate and their logistical requirements are great, Bureau of Land Management fire control personnel look for other methods of meeting these transportation needs.

Many of the hours flown by helicopters assigned to project fires involve movement of personnel, equipment, and supplies from one portion of the fire perimeter to another. Much of this activity, such as food distribution, is routine; if needs are anticipated, the speed of a helicopter is not required. Use of tracked vehicles capable of transporting personnel and negotiating streams, lakes, and swampy areas is considerably less expensive. Due to the vast distances separating the road net from these fires, aerial delivery of these machines is necessary. When the fire is out, these vehicles can be driven cross country to the nearest airstrip at leisure, and flown back to the fire-control headquarters.

The feasibility of delivering these vehicles by parachute was explored. Through the cooperation of the U.S. Army, Alaska, a carrier was rigged for paradrop by the USARAL Support Command's parachute maintenance branch at Ft. Richardson. The experimental drop was made from a U.S. Air Force C-119 Flying Boxcar.

Description of Carrier

A Bombardier BB Carrier was used. It has a cross-country cruising speed of 15 m.p.h. and is amphibious when equipped with an outboard motor. It has a water-cooled, four-cylinder, 57-hp. Simca Flash Special engine. The vehicle rides on tracks 27 inches wide which are supported on rubber wheels. It is approximately 94 inches long, 72 inches wide, and 46 inches high. Up to six men or 1,000 pounds of cargo may be moved. For added utility, mounts were installed to accommodate a small hydro pump and a 55-gallon water tank.

Rigging

During the fire season the Bombardier sits on an 8-foot-square drop platform. For added strength, ¾-inch plywood on a 2- by 6-inch frame was used. Two lengths of 18-inch-wide honeycomb cardboard 6 inches thick were placed under each track. The center hull of the vehicle was also supported by four columns of the same material. Fourteen lengths of parachute webbing on the sides, front, and rear secured the platform to the carrier. Lifting eyes, able to withstand a 4-G opening shock, were welded to the four corners of the carrier frame, and the cargo sling was attached. The rear engine mounts were also strengthened to stand opening shock. An Army Type G-11A 100-foot cargo parachute was attached to the sling, with its 15-foot extraction parachute (fig. 1). The final rigged weight, including the platform, cardboard, and parachute, was 2,730 pounds.

Dropping

The carrier was dropped at an altitude of 1,500 feet. The wind was light and variable, with a surface speed of 5 to 8 m.p.h. Extraction of the load and subsequent deployment of the cargo canopy was normal. A 15-foot chute was used to pull the load from the aircraft. The opening time of the cargo canopy was

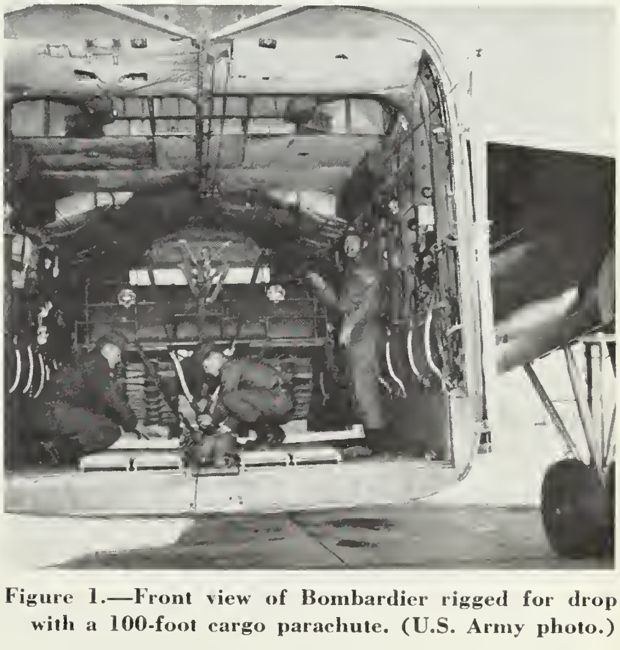

Figure 1.—Front view of Bombardier rigged for drop with a 100-foot cargo parachute. (U.S. Army photo.)

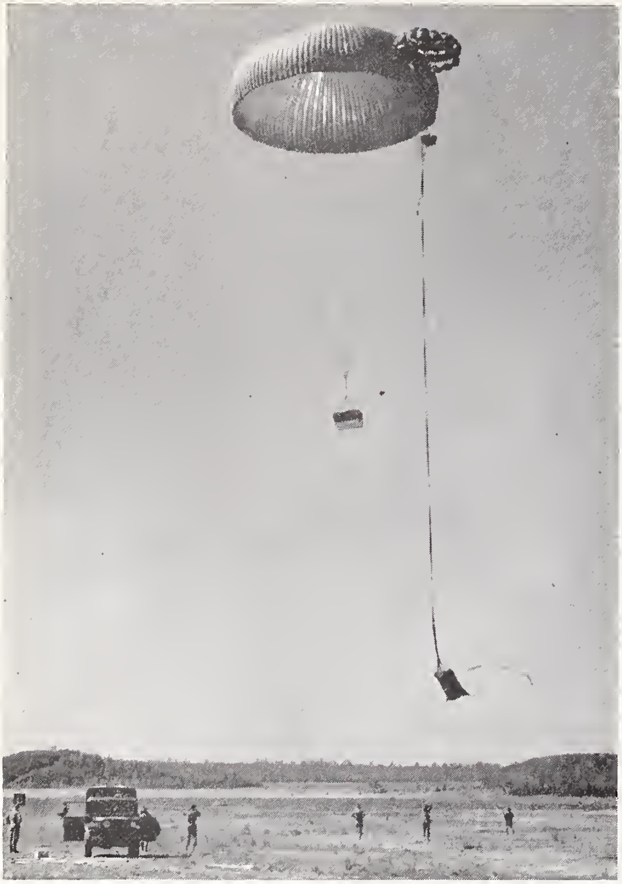

Figure 2.—Bombardier just before impact. The extraction chute in the foreground is falling free.

Figure 3.—Bombardier immediately after the drop.

6 seconds, considerably longer than the normal opening time for personnel chutes. Immediately after the cargo canopy came out, the extraction chute broke free and fell separately. Once the canopy was fully deployed, and throughout the descent, oscillation was negligible (fig. 2). The platform and carrier landed in a flat position, skidding after impact approximately 10 feet over level ground in the direction of the surface wind.

Inspection After the Drop

Immediately after the drop, ground inspection revealed no damage to the Bombardier (fig. 3). The platform was also undamaged; however, it is considered expendable. The honeycomb cardboard remained intact, showing only dents from the wheels and metal cleats of the tracks. Within 10 minutes after the drop the carrier was driven off the platform in good operating condition.

Conclusions

Aerial delivery of personnel carriers appears feasible when a suitable drop zone is available within a few miles of the fire. Although further tests in various drop areas must be evaluated, steep ground and/or timbered areas probably should be avoided because the cargo may overturn just prior to impact or may roll on impact. The flat and rolling tundra plains of interior Alaska have many square miles of suitable drop area. Military aircraft and riggers are able to paradrop loads up to 18,000 pounds; therefore, aerial delivery of even heavier equipment to remote fires can be considered.

HALLIE DAGGETT

Adapted from the LOG, *California Region, U.S. Forest Service, November 15, 1964*

On Monday October 19, 1964, death brought an end to the colorful career of Hallie Daggett of Etna, Siskiyou County, Calif.

Daughter of a Salmon River pioneer miner, Miss Daggett became the first woman lookout in the United States in June 1913 at Eddy Gulch Lookout on the Klamath National Forest. The ranger took her up to the log cabin and left after giving her a rough map of the area. He instructed her to report any fire she saw by calling him on the grounded telephone line connected to his office at Sawyers Bar.

The idea of a woman being a lookout was novel to the people of the area, and she had many visitors to that lonely spot. People wondered if a woman really had what it took to be a lookout. However, she established a tradition, for more than half of the lookouts in California are now women.

THE HELICOPTER CARGO NET

JEFFERY R. DAVIS, *Supervisory Smokejumper, Aerial Fire Depot, Missoula, Mont.*

Introduction

The 8-foot-square helicopter cargo net, with a connecting "spider" suspension system, provides an efficient implement for transporting cargo used in Forest Service field operations.[1]

The net, suspended below the helicopter and released by the helicopter bombshackle device, facilitates handling of odd-sized cargo bundles without prepackaging. It will easily accommodate the helicopter's maximum payload.

Type VI nylon webbing is the most satisfactory material used in the nets. Type VIII cotton webbing may also be used: it satisfies minimum tensile strength and construction demands. Nylon is preferred because it costs less, is more durable, and has less bulk and weight.

The nylon "spider" suspension system, connecting the four corners of the net to the helicopter bombshackle (fig. 1), is constructed of 1-inch tubular webbing.

The nets can be used in any area or job where helicopters can operate (fig. 2). More than 50 have been constructed at the Aerial Fire Depot parachute loft in Missoula, and these are now used on many National Forests in Region 1.

Value

The net is particularly useful in transferring cargo from wilderness forest fire sites to more accessible

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[1]Detailed plans are available on request from the Regional Forester, U.S. Forest Service, Missoula, Mont.

Figure 1.—Helicopter cargo net loaded and secured to helicopter bombshackle by nylon suspension straps.

Figure 2.—Helicopter in flight showing cargo net in operation.

NORTHERN CHEYENNE MODEL FIRE DRAG

W. Howard Welton, *Forester, Bureau of Indian Affairs, Lame Deer, Mont.*

While grass fires have low resistance to control, rapid action is needed to keep them small and to suppress them. We desigued an effective chain drag that can be handled by one man and can be kept in vehicles normally used where grass fires occur. The first unit was built during the 1964 season. No grass fires subsequently burned, but results from experimental fires were rewarding.

The unit consists of six 3/8-inch chains 3½ feet long bolted to an angle iron bar and dragged by a boom on the front bumper (fig. 1). Four-inch crossbars of 3/8-inch-round steel bars are welded to the last 33 links of each chain. The crossbars are welded on opposite sides of parallel links, giving the unit uniformity. All bolts must be riveted (fig. 2).

Figure 1.—The fire drag in operation.

The boom is made of two sections of pipe. The outer pipe has an inside diameter of 2½ inches. It is fastened to the front bumper by U bolts made of 3/8-inch steel rod. The inner pipe has an inside diameter of 1½ inches. Both pipes are drilled with 9/16-inch holes 1 inch from each end. The larger pipe is also drilled about one-third of its length in from each end. The inside pipe is held in place when not in use by dropping a ½-inch bolt through the end holes of both pipes. The bolts are drilled at the bottom and fastened with cotter pins. When the boom is to be used, the bolts are removed, the inside pipe slides outward two-thirds of its length, and one bolt is placed through its end and the corresponding hole in the outer pipe. The second bolt is replaced in the end, which now extends to the side of the vehicle.

The drag is pulled by placing the grab hook of any size of tow chain in the middle link of the yoke (fig. 2), and fastening it to the boom with a clove hitch. The end bolt runs through the clove hitch and holds it in place at the end of the boom. The length of hitch must be adjusted to prevent the rear wheel from running onto the drag during turning.

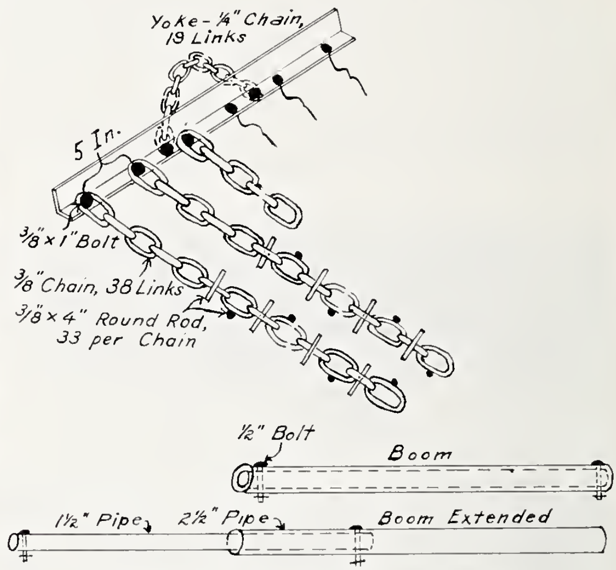

Figure 2.—Diagram of fire drag.

The drag moves forward or backward, so the operator can back up to cover the missed portion of a fire. It is also effective in mopping up because it will separate and smother burning manure. While the jeep appears to be the optimum vehicle (fig. 1), any vehicle that can reasonably negotiate the terrain involved can be equipped and used.

Specifications for the fire drag follow:

Material	*Estimated cost*
1 — Angle iron (1½ × 1½ × 3/16 × 27 inches)	$ 0.70
1 — Chain (¼ × 17 inches)	.32

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FIRE PREVENTION MESSAGE FROM THE AIR

Branch of Fire Control, *North Central Region, U.S. Forest Service*

Forestry technician Ross K. Marion of the Clark National Forest in Missouri observed an aircraft towing a banner over Poplar Bluff one day and noticed that everyone was watching and reading the message. He felt this would be a good way to present a fire prevention message to the many deer hunters and other users of the National Forest.

Ross's suggestion was adopted, and a banner is now being towed on the Clark and Wayne-Hoosier National Forests of the North Central Region. The banner has 18 nylon letters 5 feet high and reads "Prevent Forest Fires."

The aircraft towing the banner (fig. 1) is equipped with a PA system, and the pilot broadcasts another message. Flights are conducted over towns, recreational areas, and football and baseball games — any place where there are large crowds within or adjacent to the Forest protection area.

This method of fire prevention has reached many people, and the cost of this operation is far less than for the normal direct methods. Many favorable comments have been received from the public; the banner apparently is a very effective prevention tool.

The Regional Forester, Milwaukee, Wis., will furnish on request detailed information on purchase costs and operational procedures.

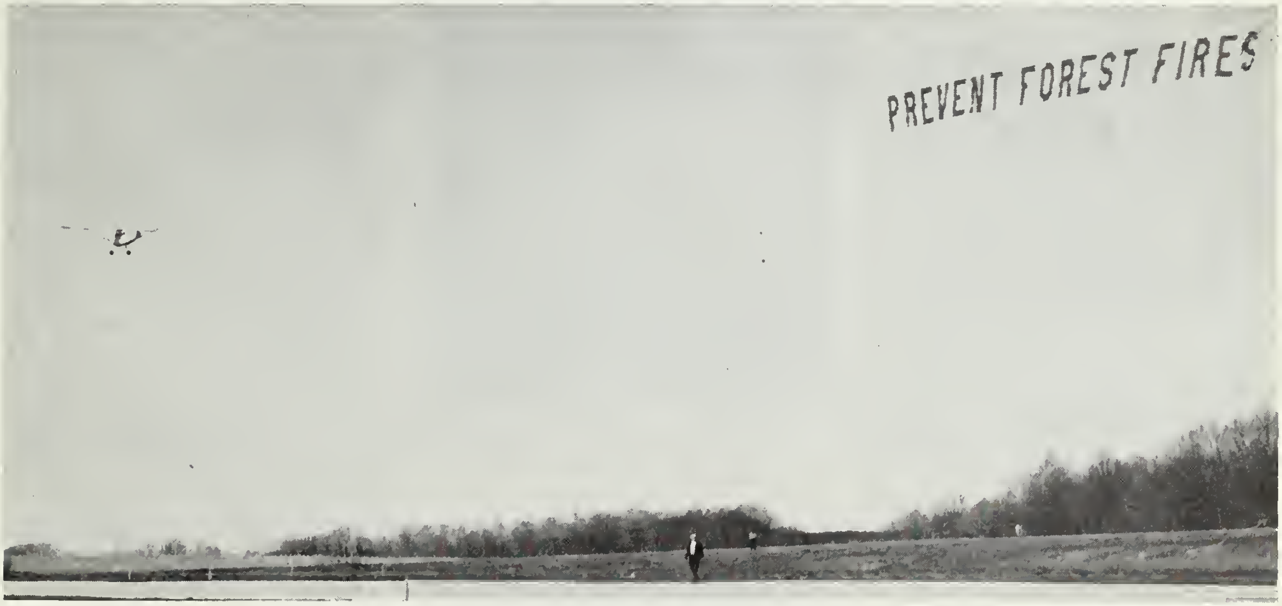

Figure 1.—Plane towing fire prevention banner.

Fire Drag — *Continued from page 12*

6 — Chains (3/8 × 42 inches)	7.70
198 — Round bars (3/8 × 4 inches)	4.95
1 — Pipe (2½ inches i.d. to fit bumper)	5.10
1 — Pipe (1½ inches i.d. to fit bumper)	2.40
8 — Bolts (machine 3/8 × 1 inch)	.30
6 — Flat washers (3/8 inch)	.05
2 — Lock washers (3/8 inch)	.05
Welding	30.00
Total	$51.57

Every 15 seconds a fire breaks out some place in the United States, according to the National Fire Protection Association.

Preplanned escape measures might save up to 85 percent of all lives lost in home fires, National Fire Protection Association studies show.

FIRE TIMEKEEPER'S "CREW ORGANIZER"

STANLEY S. TORNBOM, *Timber Management Assistant, Deschutes National Forest*

Three systems of recording fire time, the alphabetical, the numerical, and the crew system, are named according to the manner in which fire time reports are filed for use in fire camps. The method of filing determines the procedures in posting daily time for firefighters, and in processing men for transfer and release.

The crew system is recommended whenever it is possible to use it.

The primary deterrent to use of the crew system is lack of facilities in fire camps for filing and storing time reports. Small boxes, large envelopes, and large paper clips or clamps have been used. However, there is always danger of losing time reports or of getting them mixed. Lack of proper facilities for the crew system has encouraged the use of the less efficient alphabetical and numerical systems because time reports can be easily filed alphabetically or numerically in a standard 5- by 8-inch cardboard box.

The fire timekeeper's "Crew Organizer" (figs. 1, 2) is a portable unit that can be carried to a fire camp by plane or auto and can quickly be set up on the ground, or on a table, or can be attached to a tree, post, or wall. If it rains, the units can be folded to protect the time reports; if the camp is moved, the units can be folded and moved intact to the new location.

The time reports are filed by crews as men arrive at the fire camp, or as they are organized into crews. Crew names and the number of men in each crew are written on the plastic strips above the clamps to identify the crews.

Crews may be divided into four groups consisting of day and night Forest Service personnel and day and night non-Forest Service personnel. On a large fire, one crew organizer may be used for each of the four groups; on a smaller fire, two organizers can normally handle all four groups.

Unposted crew time reports can be placed on top of the fire time reports and when posted, they can be placed behind the time slips. Consequently, all data pertaining to each crew is in one place. Also, the following items can be quickly checked:

(1) The number of men, by day and night shifts, working on a fire
(2) Whether their time has been posted
(3) Names of crews
(4) Overhead

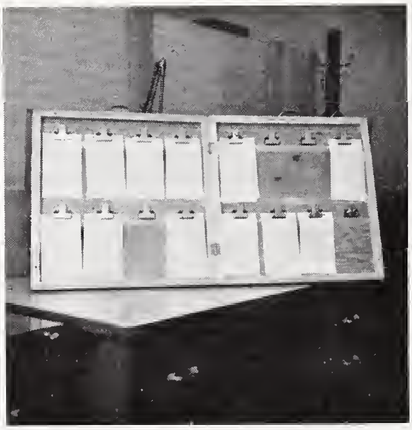

Figure 1.—The crew organizer shown fully extended, propped on legs, and locked into position.

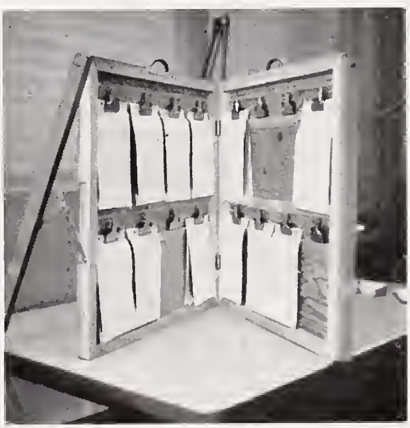

Figure 2.—The crew organizer, partially opened to show hinging and leg construction.

Used as described, the crew organizer becomes the nucleus of the timekeeper's organization and facilities.

If organizers are not available in a fire camp, the same results can be approximated if a building is available where nails can be driven into the wall, or where clips can be attached. If nails are used, they should be about 16d common nails, and the heads should be cut off after they are driven. The time reports can be hung on the nail by the center hole in the top of the time report. Names of crews and other pertinent data can be entered on masking tape placed above the time reports.

If no building is available, a unit can be built by setting two posts in the ground and nailing a few surfaced boards or a piece of plywood to the posts. Then nails or clips (Esterbrook ball bearing #20 or equal) can be mounted to this surface. If nails are used, a heavy weight must be placed on top of the time reports to keep them from blowing away.

These alternative methods describ-

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"QUICK" MOUNT FOR TOOLBOXES

JAMES R. CROUCH, *Management Analyst,*
Division of Administrative Management[1]

Have you ever wanted to mount or remove a ½-ton pickup toolbox in a few minutes? It can be done.

The folks on the Neches Ranger District in Texas and on the Yazoo-Little Tallahatchie Flood Prevention Project in Mississippi have a simple method—the "Quick" mount. Using this method, two men can quickly load or unload a box. This method saves man-hours and permits more flexibility in the use of pickups.

For example, one less vehicle may be required to do your work. When a crew is hauled to work, the box can be used as a seat and as a tool container. When the vehicle arrives at the job site, the box can be quickly and easily unloaded. The truck can then be used to haul bulky materials and supplies.

The components (fig. 1) of the "Quick" Mount follow:

Item	*Quantity*
Lumber, 2 × 4 × 96″[1]	2 pieces
Lumber, 2 × 4 × 48″[1]	2 pieces
Carriage bolts, ⅜ × 4″[1]	6 each
Carriage bolts, ⅜ × 2½″[1]	6 each

[1] The length will vary by truck.

Figure 1.—Components of mount: Bolts, runners, and end pieces.

Figure 2.—End piece in place.

The steps in installing the mount follow:

1. Cut runners to correct length and bolt to bottom of box, using ⅜ × 4-inch bolts.

2. Cut end pieces to correct length and notch to match runners on box. Bolt one piece to front of vehicle bed (fig. 2) and the other to tailgate (fig. 3), using ⅜ × 2½-inch bolts.

3. Place box in vehicle. Insert runners into notches at front of vehicle bed and then close tailgate (fig. 3). This locks box into place.

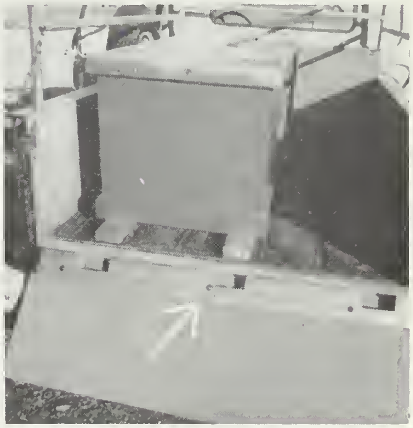

Figure 3.—End piece in place on tailgate; runners under box. (Note: Raise tailgate and box automatically locks into place).

[1] The information in this report was obtained when the author was Assistant District Ranger, Neches Ranger District, Crockett, Tex.

Crew Organizer —

Continued from page 14

ed have been used by the writer, and their use has led to the design of the crew organizer. While these methods do not provide the flexibility of the crew organizer, the basic advantages of organization and visual control still exist. It is believed to be several times as efficient as the alphabetical or numerical system.

Savings resulting from use of the crew organizer and the system described are difficult to calculate. It is estimated that in situations where the crew method is employed, use of the crew organizer and the system of visual organization reduces by 25 percent time spent by time officers and recorders.

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TOPOGRAPHIC RELIEF MAPS

Donald H. Thomas, *Fire Control Officer, Mendocino National Forest*

Figure 1.—A fire control officer indicates contour lines on a topographic relief map.

Fire control officers find that it takes more than talk to teach a new employee what a contour line is. Sand tables and other devices have been used to aid the telling by showing. The Corning Ranger District of the Mendocino National Forest purchased a set of three topographic relief maps for use in demonstrating contour lines (fig. 1).

The maps were obtained from the U.S. Army Corps of Engineers, Army Map Service, 2100 North New Braunfels Ave., San Antonio, Tex., for $2.50 each. The size of each map is 18 by 27 inches. They are printed on a rigid, heavy-duty plastic. Normal temperatuie ranges do not cause the relief pattern to distort. Horizontal and vertical scale is 1:250,000. Contour interval is 100 feet and is based on photoplanimetric methods. Horizontal and vertical control was field checked in 1957. The relief pattern is very accurate.

The map sections are constructed to allow sufficient overlap for joining sections together. The maps have proved to be a valuable training aid in our fire control work.

Helicopter Cargo Net —
Continued from page 11

pickup areas, and in engineering projects such as the transportation of bridge building equipment and lookout tower components.

In August 1964, on the Lewis and Clark Forest, the cargo nets were satisfactorily used to transport 60.000 pounds of hardware and lumber for bridge construction. The net saved time and labor, and was highly recommended by the men in charge of the project.

Specifications

The cost of materials and labor follows:

Nylon net

Webbing, type VI nylon	124 yards	@ $0.14	= $17.36
"V" rings, steel	4 each	@ $ .05	= .20
Labor	5 hrs.	@ $2.98	= 14.90
Total			= $32.46

Cotton net

Webbing, type VIII cotton	124 yards	@ $0.30	= $37.20
"V" rings, steel	4 each	@ $ .05	= .20
Labor	6 hrs.	@ $2.98	= 17.88
Total			= $55.28

"Spider" suspension system

Webbing, tubular 1-inch nylon	24 yards	@ $0.17½	= $ 4.20
Snaps, steel	3 each	@ $ .05	= .15
Labor	2 hrs.	@ $2.98	= 5.96
Total			= $10.31

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FIRE CONTROL NOTES

U.S. Department of Agriculture
Forest Service

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

CONTENTS

COVER — How would a fuel break affect this fire? **See story on p. 3.**

(NOTE—Use of trade names is for information purposes and does not imply endorsement by the U.S. Department of Agriculture.)

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VALUE OF A TIMBER FUEL BREAK—THE WET MEADOW FIRE

EUGENE E. MURPHY *and* JAMES L. MURPHY[1]

How effective are fuel breaks[2] in northern California timber country? On July 5, 1962, a fuel break on the Stanislaus National Forest (fig. 1) helped stop the Wet Meadow Fire at 23 acres. Although not a conflagration, it was the first sizable fire on the 40,000-acre Duckwall Conflagration Control Unit. Here Stanislaus National Forest personnel and fire researchers from the Pacific Southwest Forest and Range Experiment Station are studying the prevention and control of conflagrations by fuel modification through integrated land management.

Figure 1.—A planned fuel break, cleared as part of the Duckwall Conflagration Control Project, extended along the ridge at the head of the canyon where the fire was located.

VALUE OF A FUEL BREAK

Nine miles of fuel break constructed along the main ridge stopped the Wet Meadow Fire at 23 acres. Without the fuel break, the fire would have crossed the ridge into heavy brush and burned at least 60 more acres (fig. 2). About $18,000 in suppression costs may also have been saved. Thus, the $10,300 expenditure for constructing the fuel break was justified.

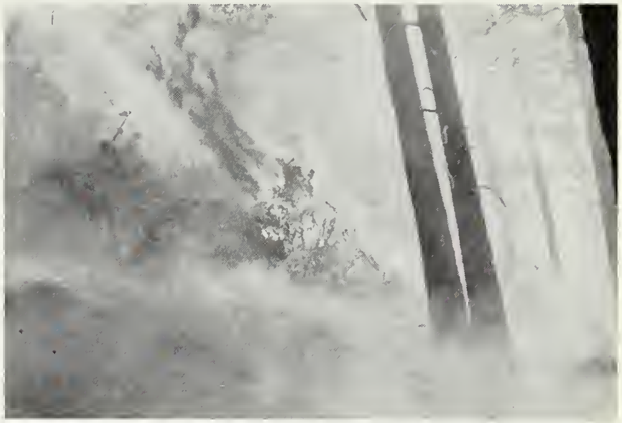

Figure 2.—The fire burned fiercely in the thick brush as it started up the steep slope and headed for the ridge where the fuel break was located.

ENGINEERING FUEL BREAKS

Local weather as well as topography resulted in a "pull and push" of the Wet Meadow Fire toward a prominent knob and a saddle. The inertia of the fire caused it to "lick over" the fuel break and to throw spot fires at these two points. The fire burned fiercely although it was only a high fire danger day (fig. 2). Erratic local winds were an important cause of the fire's behavior. Fuel breaks in timber must be widened at critical pressure points. Stocking may have to be reduced in timber country because the flames tend to flash through crowns at the edge of a fuel break.

An old cabin on private land was in the path of the Wet Meadow Fire. Though it was within the fuel-break system, brush and debris had not been cleared. Ten men took nearly one-half hour to build a fireline around the cabin. During extreme fire danger, the fire would have burned the cabin and swept across the ridge.

During the summer following the fire, private property owners on the Duckwall Unit were contacted. They were encouraged to help complete the fire-barrier system (with partial Federal financing through the Agricultural Conservation Program if desired) or to grant the Forest Service a fuel-break easement. The fire helped show landowners the importance of fuel modification, and they participated wholeheartedly the first year. The cabin incident also stressed the need for hazard reduction at other critical points, such as at campgrounds and along roads.

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[1] Respectively, District Ranger, Mi-Wok Ranger District, Stanislaus National Forest, Calif., and Research Forester, Pacific Southwest Forest and Range Experiment Station, Berkeley, Calif.

[2] FUEL BREAK—a wide strip or block of land on which native vegetation has been permanently modified. Fires that burn into a fuel break can be readily controlled because they will be of lower burning intensity and will offer less resistance to control than native vegetation.

MAINTENANCE OF FUEL BREAKS

Fuel breaks must be maintained to remain effective. The PSW Station researchers have begun a series of studies to determine the cost and effectiveness of various herbicides for control of undesirable regrowth and of soil sterilants for maintaining firelines within fuel breaks. Optimum rotation and cutting cycles for timbered fuel breaks and costs and schedules of TSI work are also being studied.

FUEL BREAKS NEED FAST, STRONG ATTACK

The Wet Meadow Fire showed that fuel modification must be combined with fast, strong attack by an efficient fire control organization experienced in constructing fuel breaks. Under severe burning conditions the fire would have hit the ridge in 15 minutes. Quick reconnaissance, probably by aircraft, would have been needed to positively locate the fire and to report its condition. Air tanker attack with 15-minute traveltime would have been required to help keep the fire from crossing the fuel break. Quick followup by ground crews would have been necessary. Traveltime for the nearest ground crews was 40 minutes. Hence, access roads must be improved, and attack crews and equipment may have to be relocated during high fire danger.

LAND DEVELOPMENT

Water developments to supplement the many miles of grass-covered fuel breaks would help utilization by livestock. They would also furnish water for fire control. Road and trail construction and maintenance would also facilitate access.

SUMMARY

A combination of fuel modification, fast, strong fire attack, and land development is necessary to control conflagrations in northern California timber country.

IMPROVED DISPATCH PLANNING

Harley E. Ripley, *Dispatcher*
Shasta-Trinity National Forest

As air tankers, helicopters, and other new tools are added to fire control, and as wild land resource values rise, initial-attack fire dispatching becomes more complex and requires quicker action.

The Shasta-Trinity National Forest uses planned area dispatching for man-caused fires. During the 1961-64 period, planned, prompt, aggressive dispatching helped hold hundreds of fires at small acreages under difficult burning conditions. These include individual and group man-caused fires, where starts occur without warning. Lightning storms usually give some warning, so the rapid dispatching allowed by the planned area dispatch system is not usually needed for lightning fires.

The system can be used with decentralized Ranger District dispatching or with centralized Forest dispatching. However, the larger the dispatching workload, the more attractive planned area dispatching becomes.

SHASTA-TRINITY AREA DISPATCH PLANNING

1. Three fire danger rating ranges and related plans applicable to conditions on the Forest are established. In the Region 5 fire danger rating system, we chose the burning index as the desired unit of measure. Definitions of the plans follow:

A. **Green plan.**—History shows the normal initial attack force (the nearest two or three crews) have controlled fires with no escapes. The burning index is 0-11 (on a total scale of 100 points).

B. **Orange plan.**—History shows some fires escape initial attack. The burning index is 12-18.

C. **Red plan.**—All-out effort is needed to control fires. The burning index is 19 and above.

2. Logical initial attack areas are established and outlined on the Forest map, and the areas are numbered or lettered for easy identification. Preattack planning blocks are used to avoid the confusion resulting from use of two sets of blocks. We often group several blocks to form initial attack areas where similar action applies to two or more blocks (fig. 1).

3. Planned initial attack and followup are developed for each area: this includes any cover needed for vacated stations. The district rangers and the central dispatcher collaborate very closely in this phase of the planning.

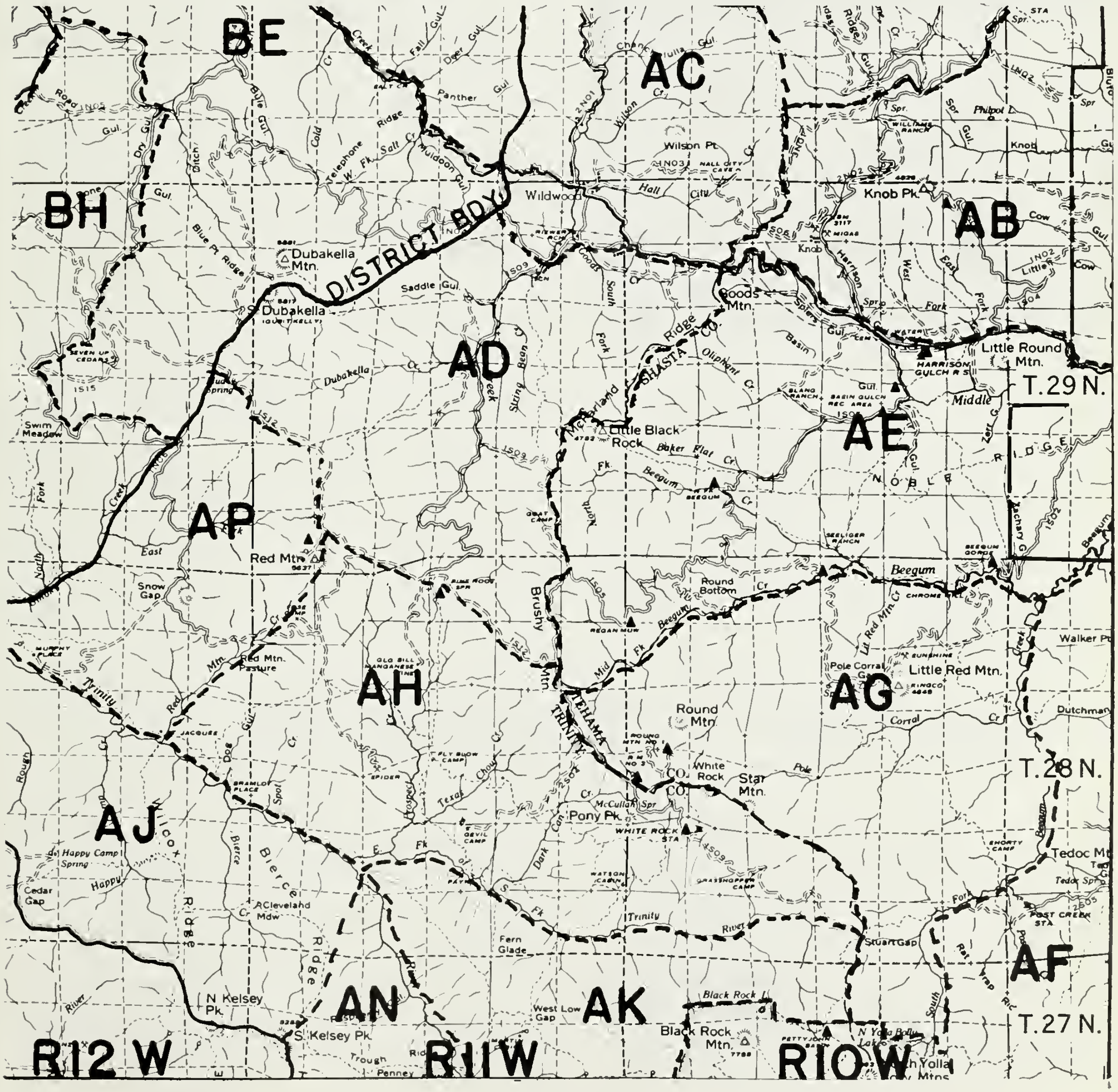
A dispatch plan is made for each area, for the three brackets of fire danger. The manpower and equipment moves are in two categories (fig. 2).

Category 1 includes manpower and equipment available to the Districts and cooperator forces. Category 2 covers such items as air tankers, smokejumpers, helicopters, and State Division of Forestry crews and equipment that are more easily contacted by the central dispatcher.

ACCESSIBILITY OF PLANS

After the plans are made, they must be widely distributed to all individuals and crews involved. In the central dispatcher's office they can be summarized on 5- by 8-inch cards; Kardex or Unisort cards are quite suitable. A master index card must be set up for each plan (green, orange, and red) to facilitate sorting the card for the block in which the fire is reported.

Figure 1.—Solid black lines indicate Forest and District boundaries. Broken black lines separote blocks. The first letter indicates the District, the second letter the block. (Area dispatch plan map)



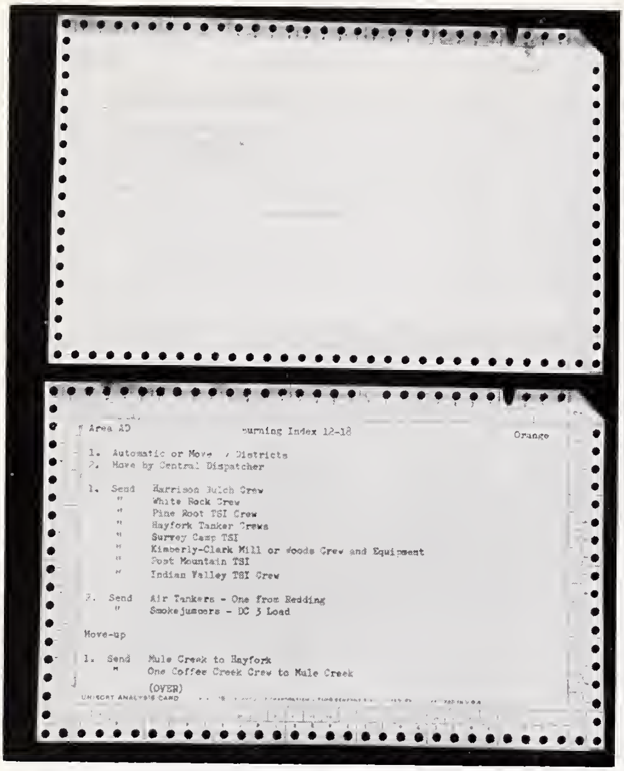


Figure 2.—Sample preplanned attack plan for Shasta-Trinity National Forest.

Each crew or individual should have an abbreviated plan and a map showing his assignment at the various fire danger locations and levels. The abbreviated field summary can be carried in a pocket notebook, with dictionary-style tabs to identify areas and color codes for various levels of fire danger. Some Districts have modified desk-top pushbutton alphabetical directories to indicate areas and activity levels.

UTILIZATION OF PLANS

When a fire is reported and the location determined on the dispatcher's string map, he announces the block letters and map location on the radio by saying, for example, "We have a fire in Block AD, Township 29 N. Range 11 W., Section 15; the dispatch plan is green." The dispatcher then rolls category 2 items as needed and checks with the District to be sure all category 1 action has started.

The District clerks check the plan for the designated block, and then start action on the District.

Men going to the fire check field copies of the plan. As the crews start to roll they announce to the fire or their planned cover position that their radio is on and in service. They later announce their arrival at the fire.

When the fire boss is sure the fire can be controlled with the forces that have arrived, he informs the dispatcher, who will hold or turn back forces that have not yet arrived.

The planned moves, which involve many people and much equipment in the moderate and high fire danger categories, may be altered when the central dispatcher or a qualified fire boss deems it advisable. The plan is to keep men and equipment rolling toward a reported fire until control is assured.

The advantages of this "instant" dispatching over the old one-at-a-time method are greatest on a large area with a heavy, diversified workload. However, this system will not eliminate the need for a competent, experienced dispatcher who must direct all actions of this system.

INEXPENSIVE REFILL DEVICE FOR SMALL TANKERS

RAY MILLER, *Area Forester*
Idaho State Forestry Department

The Idaho State Forestry Department uses numerous small tankers for initial attack on forest and range fires. These units are often operated independently of mother tankers and far from water pumping facilities.

Refilling equipment is necessary to permit continuous use of these pumpers on individual fires. An auxiliary pump, a suppression pump, or a quick-refill attachment can be used. The high-pressure, low-volume pumps mounted on the tankers are generally not satisfactory because of the long time necessary for filling and the poor suction of many low-volume pumps. Auxiliary high-volume pumps can be carried with the pumper for filling; however, the auxiliaries are expensive, and the added weight is undesirable.

The "quick-refill," using the venturi-tube principle, has been the best means of refilling tanks. The refills are small, light, and pick up much water. The cost of commercial refills, complete with accessories, is $20 to $40.

Refills presently used by the Idaho State Forestry Department are compared in table 1.

TABLE 1.—*Cost and water pickup of quick-refill venturi-tube types*[1]

Model	Approximate cost with accessories	Water pickup
	Dollars	*Gal./min.*
Hurst	([2])	13
Bean	$30	26
Penberthy	20	9
M-1, 1/8"[3]	8	20
M-2, 3/32"[3]	8	16
M-3, 5/32"[3]	8	8

[1] Input: 4½ gal./min., 300# pressure, 300 feet ½-inch-i.d. hose, Wanner pump, 1½-inch-i.d. discharge hose.
[2] Unknown.
[3] Orifice diameter in jet.

In use, ½-inch hard line hose is attached to the refill with the swivel joint (fig. 1, item 13), and the filler hose is attached to the opposite end. The entire refill is placed in the water source, and the end of the filler hose is put into the storage tank. The pump is started as in normal operations, and the tank is filled.

The M-1, M-2, and M-3 units are shop-built refills similar to the one shown in figure 2. The only significant difference between the units is the size of the hole in the jet. The hole size can be varied to fit pumps of various capacities. Results obtained from all units of these refills during the 1964 fire season were satisfactory.

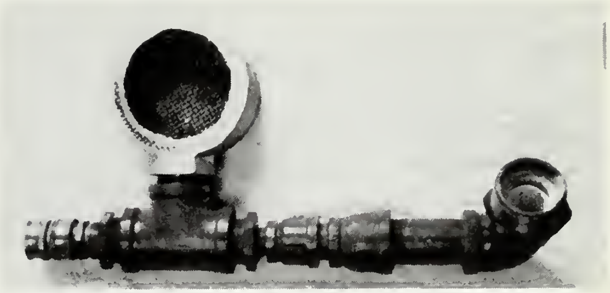


Figure 2.—Shop-built refill.

These shopmade units cost less than $7 and require less than 1 hour to build. They should be painted with a high-grade epoxy paint to protect the parts from corrosion. The following items, used in the fabrication of these refills, are numbered according to the numbers shown in figure 1.

Item No.	Description	Cost
1.	1" brass-close nipple	$0.51
2.	1" 90° elbow	.16
3.	1" × 2" 3" nipple	.07
4.	1" ¾" bell reducer	.17
5.	¾" close nipple	.04
6.	¾" ½" bell reducer	.17
7.	½" close nipple	.03
8.	½" × 1" bushing	.09
9.	1" "T"	.23
10.	¾" × 1" bushing	.09
11.	½" airhose coupling	.55
12.	¾" HT-¾" and ½" pipe adapter	.25
13.	¾" HT—double female swivel	.25
14.	1" brass close nipple	.51
15.	Intake screen (Western Fire)	3.50
	Total	$6.62

(Continued on page 9)

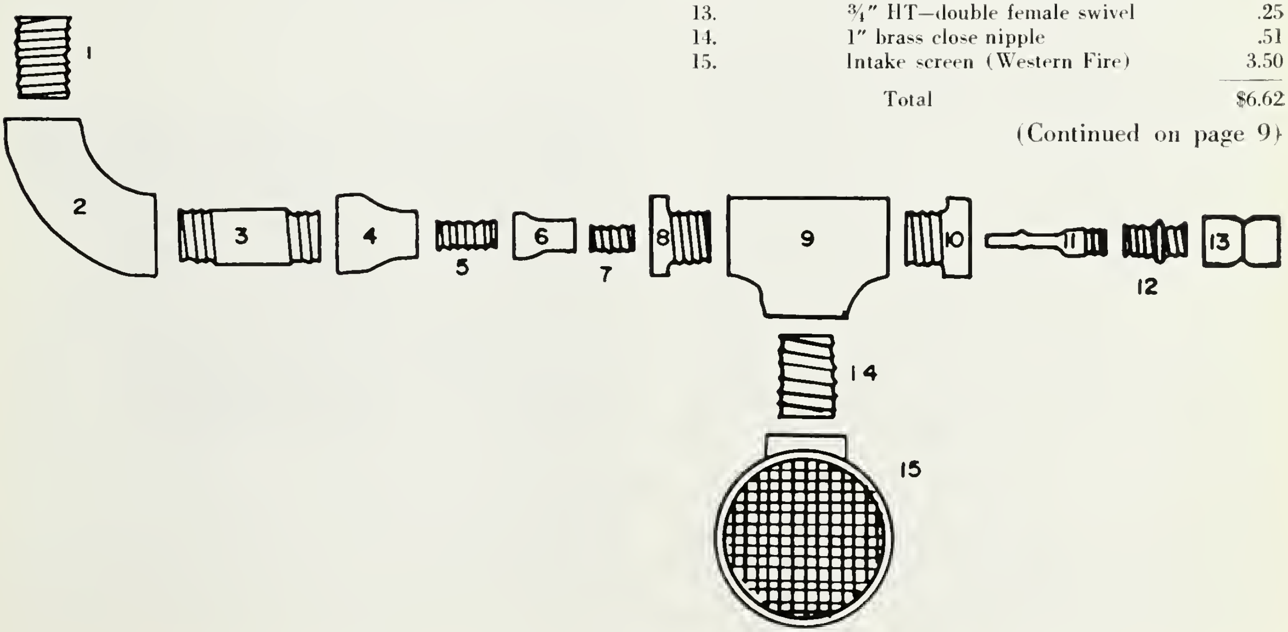


Figure 1.—Diagram of assembly.

BACKPACK MIST BLOWER AS A FIRELINE BUILDER

John F. Welsh, *District Ranger,*
Buffalo District, Ozark-St. Francis National Forest

The backpack mist blower has been an effective forest fire fighting tool in the pine-hardwood and hardwood types of the Arkansas Ozarks. The machine was designed for application of liquid herbicides and insecticidal dusts, but without special adaptations it also has been used for airblasting firelines. The blower is used primarily to remove fine, loose fuel from the proposed fireline.

Most of this material is hard to move effectively with handtools, and even when a plow can be used safely, most of the material falls in behind the machine. A properly directed airblast quickly moves most of the material. Effectiveness depends on many factors, including quality, quantity, size, and compactness of fuels; steepness of terrain; and rockiness of soil.

Earlier Uses of Blowers

A wheeled blower was developed in the late 1950's to clear hardwood leaves from firelines in Missouri.[1] In 1962, a backpack mist blower was used to apply water in fire suppression.[2] However, use of the backpack mist blower for airblast line building is apparently new.

Site Conditions

Arkansas Ozark fuel types are medium to high in both rate of spread and resistance to control. Hardwood leaves usually are the most conspicuous and troublesome component. Soils are thin and rocky. Topography consists of broad, flat ridgetops and rough, steep drainages, with vertical bluffs not uncommon. Rocks and steep slopes preclude wide use of plow units, and steep terrain reduces the utility of a wheeled blower. Because of rising watershed, timber, and wildlife values, slow and inefficient fire suppression with handtools outside the plowable area can no longer be tolerated. The backpack mist blower is one good answer to the difficult fuel, soil, and topographic conditions.

Instrumentation

The mist blower used to suppress fires on the Buffalo District of the Ozark-St. Francis National Forest is the Model KWH-75, manufactured by Kiekens Whirlwind of the Netherlands (fig. 1). It has an air-cooled, two-cycle engine with 6,000 r.p.m. The fuel tank capacity is 0.6 gallon. The blower was not basically modified; however, the unneeded herbicide tank, valves, tubing, etc., were removed to reduce weight. The weight of the blower without the mist tank is 35 pounds. The blower delivers 435 cubic feet of air per minute through a bent metal tube, under the operator's right arm, into a flexible hose about 5 inches in diameter and 3 feet long. The flexibility of the airhose permits the operator to direct the jet of air.

Personnel

Recommended personnel for building firelines with the mist blower consist of a line locator, a blower operator, and a followup crew. The line locator also breaks up matted fuel beds with a fire rake (Council Tool). The blower operator constructs line of the desired width and cleanness by varying his speed of advance and the degree of lateral swing of the air nozzle. The followup crew usually consists of one to four men, depending on the amount of matted or coarse fuel, the difficulty of holding the line, and, of

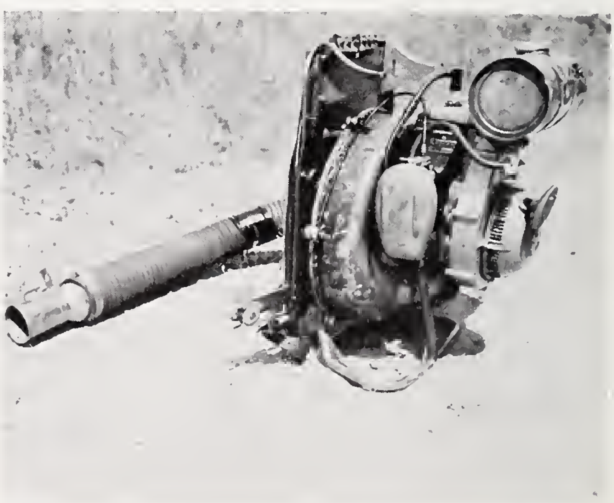


Figure 1.—The stripped-down backpack mist blower ready for action.

[1] Nichols, J. M., and Paulsell, L. K. A new idea in firefighting: air blast line building. Univ. Mo. Agr. Expt. Sta. Bul. 725, 7 pp., illus. February 1959.

[2] Lashley, O. L. Backpack mist blower for fire suppression. Fire Control Notes 23(4): 107, illus. October 1962.

course, the availability of manpower. Trained followup crewmen serve as relief blower operators.

For each man-hour, a trained crew can construct 18- to 20-inch firelines about 13 to 25 chains long, depending on amount of fuel, slope, rocky soils, etc. On February 12, 1962, a Class 4 fire day, 14 men and 2 blowers controlled the Koen Fire at 129 acres. Within $2\frac{1}{2}$ hours after initial attack, they built and held 190 chains of fireline at the rate of 5 chains per man-hour. Blowers have since been used on all fires except those that were controlled by other means before a blower could be dispatched (fig. 2).

Summary

Some advantages of the backpack mist blower are:

1. Low cost: about $300.
2. Versatility: The mist blower can be used in timber management and other functions outside the fire season.
3. Portability in rugged terrain: The blower can be used where a man can walk safely.
4. High effectiveness in clearing fuel between small rocks where handtools cannot reach (fig. 2).
5. Speed: Fireline is built almost as fast as a slow walk.
6. Low skill requirements: Inexperienced men learn to use it quickly.

Some disadvantages of the blower are:

1. Ineffectiveness in coarse or matted fuels and in dense, low brush.
2. Inability to build fireline down to mineral soil.
3. Possibility of mechanical failure.

Special safety precautions to be observed in using the mist blower in fireline construction are:

1. Protect eyes of blower operator and nearby workers from flying particles.
2. Be sure of footing while carrying blower.

Figure 2.—Fireline cleared by the mist blower through an area too rocky for plowing or effective use of handtools.

3. Pick escape route to prevent heavily laden blower operator from being trapped by fast-moving fire.

Experience indicates safe, dependable, effective operation can be achieved rather easily. Advantages of fireline construction with the mist blower definitely outweigh disadvantages under the conditions described. Therefore, the backpack mist blower should be a powerful new fire suppression tool under certain fuel, soil, and topographic conditions.

Refill Device—(Continued from page 7)

The refill shown in figure 1 is designed for use with a 1-inch filler hose. If $1\frac{1}{2}$-inch filler hose is used, item two can be exchanged for a 1-inch street elbow and item one for a 1- by $1\frac{1}{2}$-inch brass bushing (fig. 2). Use of a 1-inch filler hose slightly reduces the volumes, according to table 1, that are picked up by the refill. The surface of item one that contacts the gasket of the filler hose may need facing to prevent cutting of the gasket and to insure a good seal. Item 11 is the jet that provides the power for the refill. It is constructed from a $\frac{1}{2}$-inch air-hose coupling. The small end of the hose coupling is filled with bronze, and a $\frac{1}{8}$-inch hole is drilled in the center of the weld. The hole sizes may be varied according to the volume of the pump and its operating pressure. The hexagon corners of the hose coupling must be ground off in order for it to pass through the hole in item 10.

THE EFFECT OF THE EARTH'S CURVATURE IN VISIBILITY MAPPING

C. E. VAN WAGNER,[1] *Fire Research Officer*
Canadian Department of Forestry

The profile method of drawing visibility maps has been well described in the literature. e.g., by Show et al. (1937)[2] and by Catto (1960).[3] Using good contour maps, reasonably accurate visibility maps can be drawn in the office. However, field checks are advisable. The techniques of field sketching are covered by Show et al. (1937)[2] and by Chorlton (1951).[4]

There are two variations of the profile method. In one, vertical profiles along lines radiating from the tower are plotted separately, and lines of sight are drawn to the successive ridges; the visibility information is then transferred to the radial lines on the map. In the other, use of a profile board permits the operator to plot visibility directly along the radial lines on the map without first plotting the profiles. A movable arm pivoted at the tower position is set at a different angle for each line of sight, and a vertical scale laid on its side is used to determine whether points on the other side of intervening ridges are visible.

Several sources of error in the profile method (e.g., height of trees on ridges, projection of ridges above highest contour, and doubt of exact tower elevation) are well-known, but there is one source that is not mentioned in the literature. This is the effect of the earth's curvature.

A formula is used to determine if that effect is large enough to be considered. In surveying, the vertical depression of distant points due to the earth's curvature is given in feet by $0.667\,K^2$, where K is the distance in miles. In practice, atmospheric refraction curves the line of sight slightly downward, reducing the apparent error to $0.574\,K^2$. Table 1 shows the depression in feet for distances of 1 to 20 miles. The actual errors in screening are always less than the figures given because the intervening ridge is lowered by the earth's curvature. Consider figure 1. T is a lookout tower, R is an intervening ridge at distance x from T, and P is a point at distance y from R. The dotted lines represent a flat-earth surface and the resulting plotted line of sight, the solid lines the curved-earth surface and true line of sight. The point P is screened from sight by the vertical interval between line of sight and the earth's surface; the interval is apparently greater in the curved-earth model than in the flat-earth model. The question is: How much greater?

TABLE 1.—*Depression due to earth's curvature and atmospheric refraction*

Distance	Depression	Distance	Depression
Miles	*Feet*	*Miles*	*Feet*
1	1	11	81
2	3	12	96
3	6	13	113
4	11	14	131
5	17	15	150
6	24	16	171
7	33	17	193
8	43	18	216
9	54	19	241
10	67	20	267

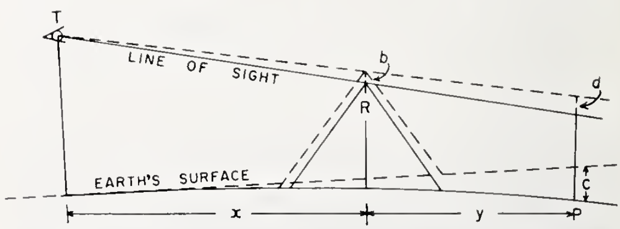


Figure 1.—Diagram of effect of earth's curvature in visibility mapping with exaggerated vertical scale.

The position of P is lowered by the earth's curvature an amount c, equal to $0.574(x+y)^2$. The line of sight is lowered an amount d, due to the depression of the ridge R by an amount b. But d bears to b the same ratio as the distances of P and R from T. That is,

$$\frac{d}{b} = \frac{x+y}{x}$$

but $$b = 0.574\,x^2$$

therefore $$d = 0.574\,x^2\,\frac{(x+y)}{x} = 0.574\,x\,(x+y)$$

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[1] The author is stationed at the Petawawa Forest Experiment Station, Chalk River, Ontario.

[2] Show, S. B., Kotok, E. I., Gowan, G. M., Curry, J. R., and Brown, A. A. Planning, constructing, and operating forest-fire lookout systems in California, U.S. Dept. Agr. Cir. No. 449. 1937.

[3] Catto, A. T. Visibility maps for fire protection. Pulp and Paper Mag. of Canada, Woodlands Rev., Conv. Issue: 4-20, 41. 1960.

[4] Chorlton, R. W. The preparation of visible area maps by field sketching. Canada Dept. Resources and Devlpmt., Forest Fire Res. Note No. 16. 1951.

The net error in vertical screening equals c — d and is always unfavorable because c is always greater than d.

$$\text{Error} = c - d = 0.574(x + y)^2 - 0.574\,x\,(x + y)$$
$$= 0.574\,y(x + y)$$

The error is in feet, and the distances are in miles.

That is, the net error depends on the product of the distances from tower to point and from ridge to point: it is slight for points just past an intervening ridge regardless of distance, and substantial only for points far past a ridge. Table 2 shows the net error for a few sample configurations. The vertical errors due to the earth's curvature would be least in hilly country abounding in ridges because each would limit the line of sight for a short distance. In mountainous country the vertical errors would be small compared with the great variations in screening below line of sight, and the horizontal errors in visible area would be slight on steep slopes. *It is in fairly level topography with only a few ridges, each limiting the line of sight for a considerable distance, that the appearance of a visibility map might be considerably altered.* The effect of vertical errors would be more important on a map showing different degrees of vertical screening rather than simple visible area.

TABLE 2. — *Net curvature errors for some combinations of distances from tower to ridge and ridge to point*

Distance		Net error	Distance		Net error
Tower to ridge	Ridge to point		Tower to ridge	Ridge to point	
Miles	*Miles*	*Feet*	*Miles*	*Miles*	*Feet*
5	1	3	15	1	9
5	5	29	15	5	57
5	10	86	15	10	143
10	1	6	20	1	12
10	5	43	20	5	72
10	10	115	20	10	172

(A potential pitfall in separating lightly and heavily screened areas with the profile board deserves mention here. Screening is understood in the vertical sense, not perpendicular to the line of sight. A negative error results if degrees of screening are marked on the movable arm, or if the width of the arm is used to separate light and heavy screening. This error is due to the exaggerated vertical scale and equals the difference between A B and A C in figure 2. The angle α of the movable arm is obviously the same as the angle B A C. Therefore, A B equals A C cos α. The error amounts for instance, to 14 percent of A C when α is 30°, or to 29 percent when α is 45°.)

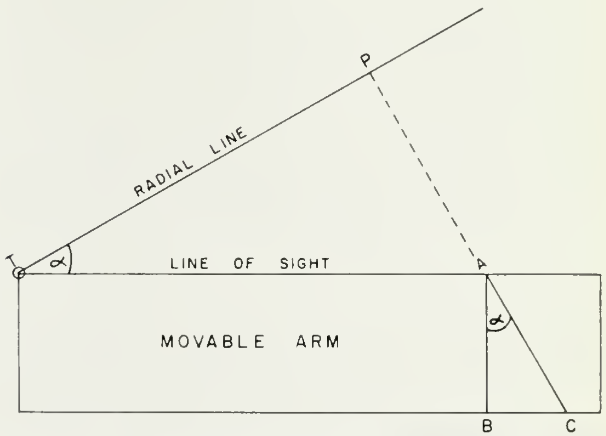

Figure 2.—Effect of measuring degree of screening perpendicular to line of sight instead of to earth's surface. True screening is along A C.

Whether the earth's curvature should be considered in a given job of visibility mapping can be judged by comparing some typical curvature errors in the tower area (consult table 2 or use formula) with the accuracy desired. The correction is readily made if profiles are plotted — each plotted elevation is reduced according to its distance from the tower (see table 1), and the drawn lines of sight will then be in the correct positions. If the profile board is used, a correction must be made both at the ridge when setting the line of sight and to each subsequent point as it is tested; alternatively, the upper edge of the board can be cut to the proper curve and placed tangent to the radial line at the tower.

According to the National Fire Protection Association, the two largest single property-loss fires of 1964 probably occurred at Walker Air Force Base, N. Mex. On February 13 and on March 9, fire and explosion destroyed missile launching facilities. Each incident cost about $11½ million.

U.S.S.R. FOREST FIRE RESEARCH AND METHODS OF FIRE CONTROL[1]

VALENTIN G. NESTEROV, *Head Forestry Chair*
Timiryasev Agricultural Academy, Moscow, U.S.S.R.

U.S.S.R. forests contain 25 percent of the world's forest resources. Much attention is given to the protection of these forests from fires. An effective fire control system is the main component of forest fire research. It is used to regulate the type and amount of fire-prevention measures used throughout the country.

A system of forest fire protection was first expounded by the author in 1939.[2] As a principle of the system, we take the mathematical expression of interaction among the following components: Burning ability, fire weather, propaganda, fire-resistance characteristics of the forest, discovery and analysis of fires, and localization and suppression of fires.[3]

The fight against forest fires can be represented by a formula, with six major factors, that is perfect only when we have few fires and suppress them early. In viewing the formula, imagine two competing forces—one representing fire strength and the other fire suppression forces.

The first step in the fire control system is the division of the forest into plots—blocks of the same burning ability and, of course, of the same fire danger. This first procedure is as follows:

Neighboring plots or blocks should first be distributed into classes of burning ability.

Class I.—Coniferous stands on dry or fresh soils. and plantations of leaf-bearing forest on dry soil.

Class II.—Coniferous stands on wet and swamp soils.

Class III—Leaf-bearing stands on fresh and wet soils. (In some regions fresh leaf-bearing stands can be included in Class II).

Each class of forest blocks is subdivided according to fire danger into the following sections:

Section A.—A road is inside the section or not more than 200 meters away, or a settlement or a timber enterprise is within 5 kilometers.

Section B.—The nearest settlement is within 5 to 10 kilometers.

Section C.—It is more than 10 kilometers to the nearest settlement.

To calculate the second determinant of the system we have defined the fire danger of weather using "complex meteorological methods."

Experience gained from meteorological studies of 20,000 forest fires shows that duration of dry season, quantity of rainfall, temperature of air, vapor-pressure deficit, and windspeed are the best indices of burning ability of vegetation.

Understanding of physical processes occurring in the phenomena and the correct establishment of interaction coefficients permit us to construct the most reliable index of fire danger to forests. The general formula is:

$$T = K_1 K_2 \int F(u)\,du$$
$$\cong K_1 K_2 \Sigma\ (u)$$

where: T = burning index;
u = meteorological index for a day
= $t\ d$ where t = temperature; d = vapor-press deficit;
K_1 = coefficient representing last rainfall; and
K_2 = coefficient representing wind influence
= 1 for wind $<$6 meters/second (0–12 m.p.h.)
= 2 for wind = 6–10 meters/second (13–22 m.p.h.)
= 4 for wind $>$10 meters/second (23+ m.p.h.).

For example, let us see what changes occur in the burning ability of a forest with changes in the simplified complex index, $\Sigma\ (t\ d)$. Here one must consider the sum of products resulting from the multiplication of temperature of air, t, by vapor-pressure deficit, d, at 13.00 each day beginning from the last rainy day and ending on the day when the burning index is calculated. This determinant changes as follows:

Class I.—The index is less than 300 degree-millibars. Fires are impossible.

Class II.—500–1,000 degree-millibars. Weak surface fires can appear.

Class III.—1,000–4,000 degree-millibars. Strong surface and weak crown fires are quite possible.

Class IV.—More than 4,000 degree-millibars. Generally dangerous crown fires can result. Burning ability is very strong.

On the basis of these classes the Central Institute of Weather Forecasting publishes daily information maps

(Continued on page 14)

[1] Adapted from paper presented at Symposium on Forest Fire Research, Tenth Pacific Sci. Cong., August 1961.

[2] Nesterov, V. G. Instructions on working out a plan of fire protection measures of a forest. All-Union Res. Inst. 1940.

[3] Nesterov, V. G. Burning ability of forest and methods of its defining. 1949.

FIREFIGHTING FARM LABORERS

Morrison "Jim" James, *Forester,*
Division of I&E, Berkeley, Calif.

Forest Service fire control officers fighting wildland fires in California have seen their initial attack crews fail to stop a fire. Fast followup was required to contain the fire in the first burning period. When California is hard hit by simultaneous fires or by a large fire such as the recent Coyote Fire, the supply of local pretrained and organized crews may be exhausted. The Forest Service must then rely on crews recruited from outside sources.

Reserve Labor Supply

The City of Porterville, headquarters for the Sequoia National Forest, is in an agricultural area where farm labor requirements are only intermittently great. A labor force of several hundred men, primarily of Spanish-American extraction, lives in and near Porterville. The Forest Service has usually obtained pickup labor by contacting one or more of three labor contractors. The contractors, after assembling the desired number of men, were hired as labor leaders. Fortunately the normal fire season coincided with a period when farm labor requirements were low.

Individual laborers were hardened physically and were skilled in the use of handtools; however, many had physical defects and many could not speak English. In addition, mobilization was slow, turnover was great, and teamwork and prefire training were lacking.

The three contractors, all of Spanish-American extraction, were known by reputation and experience to be reliable, conscientious, and anxious to help the Forest Service and the farm laborers they worked with. They were classified as labor leaders and were asked to select one man as a crew leader for each 25-man crew and one man as a squad leader for each 5 to 7 laborers. The crew and squad leaders were chosen, subject to approval of the Forest Service, and a graduated pay scale was worked out, commensurate with the responsibility of the position.

Each labor leader organized three or four 25-man crews. Labor leaders and crew leaders must be able to speak English and Spanish and must attend a Forest Service training session. Crew leaders are required to have previous fire experience and a current physical examination on file with the Forest Service. Alternate squad leaders are designated to save time in making up crews. The crew man must be accepted as a mem-

Figure 1.—Porterville-organized fire crew boards chartered plane for transportation to Coyote Fire. (Courtesy of Porterville Recorder.)

ber of a crew and have a record of a recent physical examination on file. While not necessarily desirable, crew men are permitted to shift between crews. This is done primarily to reduce the time required for roundup and mobilization.

Each man on the approved list is issued a card showing his name, address, crew affiliation, and highest qualified position. This card must be presented before he is hired for each fire. The card expires when he is due for his next physical examination.

Training

Training sessions are conducted by the Forest Service and the California Department of Employment. Attendance is required of all leaders. Emphasis is on Forest Service fire organization, crew organization and function, safety, rules of conduct, and requirements for employment. The curriculum is designed to equip the native leaders to provide for crew welfare, integrity, and safety, on the line and in camp. They are expected to work under the direct supervision of a qualified Forest Service fire crew boss and operate the crew as a well-organized, skillful hand crew. The leaders do receive some training in firefighting techniques and skills. However, most instruction is on-the-job training. A crew may be suspended from the hiring list for failing to do a good job.

Results

Results have been good. About 350 trained and well-organized men are available from this source and can be bussed or flown to a fire (fig. 1). The California Department of Employment office in Porterville has the personnel and facilities to screen and sign these men in a minimum of time, day or night. During the 1964 fire season these crews were called on to fight 16 fires on seven National Forests. They worked 10,140 man-days.

U.S.S.R.— (Continued from page 12)

showing meteorological indices of the burning index of our forest areas. and issues bulletins forecasting the burning index of forests for 3 days, a synoptic period of about 1 week, and 1 month. This service enables us to discover fire at the initial stage of its development and to arrive quickly—the most important needs in firefighting.

The third point of the system requires improvement of propaganda concerning precautionary measures against fire and rules on careless handling of fire sources in forests. We use widely the extensive opportunities provided by the press, cinema, television, education, etc. We have found it useful to determine fire-prevention rules for special forestry activities—forest cleaning works, timber exploitation areas, forest settlements, etc.

The fourth point of the system involves strengthening the fire-resisting characteristics of the forest. It is of great value to clear logging debris and dead trees. to plant fire-protection forest belts, to sow fireproof grasses, to build firebreaks, to construct communication lines and roads, and to properly distribute fire-lookout towers, landing fields, and fire-chemical stations. To obtain the most efficient fire prevention, cuttings. mineralized zones, wet and grass barriers, wet forest zones. rivers, streams, and roads should divide forest areas into isolated blocks as small as possible. This is my "principle of an exclusive circle of barriers."

The fifth factor of the system is to discover forest fires as quickly as possible and to determine their characteristics. The best results are achieved by combining ground and air watch services. Great attention must be given to the use of photoelectric cells, radar, and other technical achievements.

Localization and suppression of fires is the sixth part of the system. According to my proposal different types of fire-chemical stations with motor and horse-drawn transport were organized. The following comparative coefficients indicate the speed of localization and suppression of forest fires, with different suppression techniques:

1. Digging a trench around a fire with handtools—1.
2. Horse plowing in two furrows—15.
3. Horse plowing in one furrow—30.
4. Tractor plowing—60.
5. Creation of chemical protection belts using portable sprayers—3.
6. Liquidation of fire by hand pumps—9.
7. Suppression of fire by flamethrowers—10.
8. Liquidation of fire by chemical solutions using portable sprayers—12.
9. Liquidation of fire by water using motor pumps—20–30.
10. Development of protective chemical and mineralized zones using tractors—45–60.

The fight against forest fires from the air also gives good results.

INDEX, 1965

(Numbers in parentheses are issue numbers)

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